

<b>PAYLOAD FLIGHT HAZARD REPORT</b>		a. NO: AMS-02-F01
b. PAYLOAD Alpha Magnetic Spectrometer-02 (AMS-02)	c. PHASE: <b>II</b>	
d. SUBSYSTEM: Structures	e. HAZARD GROUP: Collision, Injury	f. DATE: May 22, 2006
g. HAZARD TITLE: Structural Failure of Hardware	i. HAZARD <b>CATASTROPHIC X</b> CATEGORY: <b>CRITICAL</b>	
h. APPLICABLE SAFETY REQUIREMENTS:	NSTS 1700.7B and the ISS Addendum, 200.2, 208.1, 208.2, 208.3	
j. DESCRIPTION OF HAZARD:	Failure of AMS-02 Structures could injure crewmembers or damage the STS, ISS or other payloads. This hazard does not address non-structural pressure systems or sealed/vented container failures.	
k. CAUSES <i>(list)</i>	<ol style="list-style-type: none"> <li>1. Inadequate structural strength for worst-case loads during all mission phases.</li> <li>2. Improper Material Selection (including Stress Corrosion Cracking)</li> <li>3. Initiation of propagation of flaws or crack-like defects.</li> <li>4. Use of counterfeit, substandard or inadequate fasteners.</li> <li>5. Loosening of safety critical fasteners.</li> <li>6. Loss of structural integrity of welds.</li> <li>7. Improper manufacture and/ or assembly.</li> <li>8. Improper preload or creeping of the Cryomagnet support system straps.</li> <li>9. Damage to composite structural components during manufacturing, assembly operations, ground handling, and/or ground transportation.</li> <li>10. Degradation of composite structural components by atomic oxygen.</li> <li>11. Improper Preload of PAS</li> <li>12. Reconfiguration of Mechanical Components</li> </ol>	
o. APPROVAL	PAYLOAD ORGANIZATION	SSP/ISS
PHASE I		
PHASE II		
PHASE III		

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I. HAZARD CONTROL (CONTROL), m. SAFETY VERIFICATION METHODS (SVM), n. STATUS OF VERIFICATIONS (STATUS)		OPS CONTROL
1. CAUSE: Inadequate structural strength for worst-case loads during all mission phases. These loads include, but are not limited to: differential temperature, thermal extremes, differential pressure, depressurization and repressurization, acoustics, sloshing of SFHe, ground transportation and handling, on-orbit (including transfer operations from the Orbiter to the ISS and crew induced) and magnet forces.		
1.1 CONTROL: The AMS-02 hardware is being designed to have positive margins of safety during all mission phases (Note exception in Control 1.3). All metallic structures will be tested or analyzed to show margin to the appropriate factors of safety (FOS). For testing the margin will be shown to a 1.0 FOS to yield, 1.4 FOS to ultimate. For analyzed structures the margin will be shown to a 1.25 FOS to yield, 2.0 FOS to ultimate. Non-metallic structures will be tested/analyzed to 1.25 FOS (yield), 2.0 FOS (ultimate). (Note: Any exceptions to this control are documented in Control 1.4) Attached Table indicates FOS used and margins for structural components.		
<p>1.1.1 SVM: Review and approval of the AMS-02 Structural Verification Plan (SVP) (JSC 28792), which includes the requirements in NSTS 14046, by the JSC Structures Working group (SWG). Individual test plans derived from the SVP will be reviewed and approved by the JSC SWG.</p> <p>1.1.2 SVM: Structural analysis will be performed to the appropriate factors of safety for all load conditions. Review and approval of the AMS-02 Structural Analysis Reports by the JSC SWG.</p> <p>1.1.3 SVM: Static strength and strength model verification tests for the all-up configuration of the AMS-02 payload will be performed. Review and approval of the AMS-02 Static Correlation Report by the JSC SWG.</p> <p>1.1.4 SVM: Model Correlation. Modal test on the all-up configuration of the AMS-02 payload and sine sweep test of the Structural Test Article (STA) will be performed for dynamic math model verification. Review and approval of the AMS-02 Modal Correlation Report and STA Sine Sweep Correlation Report by the JSC SWG.</p> <p>1.1.5 SVM: Buckling analyses of the Cryomagnet Vacuum Case (VC) will be performed. Review and approval of the Cryomagnet VC Buckling Analyses by the JSC SWG.</p> <p>1.1.6 SVM: Proof pressure test of the Cryomagnet Flight VC and the Structural Test Article (STA) VC will be performed. Review and approval of the Cryomagnet Flight VC and STA VC Proof Pressure Test Report by the JSC SWG.</p> <p>1.1.7 SVM: An operating test of the Cryomagnet to 1.1 times the limit load will be performed. Review and</p>		

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approval of the Cryomagnet Operating Test Plan and Test Report by the JSC SWG.		
1.1.8 SVM: Qualification, acceptance, fatigue and development static and dynamic tests on the cryomagnet support system straps will be performed. Review and approval of the Cryomagnet Support System Straps Verification Test Plans and Test Reports by the JSC SWG.		
1.1.9 SVM: Acoustic analysis of the TRD, TOF, TCS and Si Tracker has been performed (other items are not acoustic receivers). Acoustic test of the STA VC will be performed. Review and approval of the Acoustic Analyses, Acoustic Test Plan and Acoustic Test Report by the JSC SWG.		
1.1.10 SVM: Sine sweep, "smart -hammer" or modal testing, or analysis (by subsystem) will be performed to verify the first natural frequency of any secondary structure with a global mode that is below 50 Hz. Review and approval of the Sine Sweep, "Smart -Hammer" or Modal Test Plan, analysis methodology (part of the SVP) and Test Report by the JSC SWG.		
1.1.11 SVM: Static verification tests of the Payload Attach System (PAS) and Interface Verification Test (IVT) of the PAS to ISS S3 Zenith Inboard Active PAS 2 were performed. Review and approval of the Static Test Report and IVT verification memorandum by the ISS Structures Team.		
1.1.12 SVM: Other subdetector items in the AMS-02 SVP will be verified by letters of certification per SVP.		
1.1.1 STATUS: Closed. SWG approval documented in memorandum ES2-06-003, "Alpha Magnetic Spectrometer-02 Structural Verification Plan, JSC-28792 Rev. D" date January 31, 2006.		
1.1.2 STATUS: Open. Most of Analysis is Complete, formal documents in work		
1.1.3 STATUS: Open. Static testing of full payload currently scheduled for May 2006		
1.1.4 STATUS: Open. Sine sweep test of STA VC currently scheduled for January 2006. Modal testing of full payload currently scheduled for May 2006.		
1.1.5 STATUS: Open. Nonlinear analysis presented and approved by SWG, formal documentation in work.		
1.1.6 STATUS: Open. Tests currently scheduled for April 2005		
1.1.7 STATUS: Open		
1.1.8 STATUS: Open . 1-D dynamic test, warm static test, cold static test, and fatigue test complete. Initial 1-D dynamic test report (LMSEAT-34044), warm static test report (MSAD-04-0054), Cold static test report and fatigue test report (CTG-SCL-290802) under review by SWG. Follow-on 1-D dynamic test report in work.		

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1.1.9 STATUS:	Open. Acoustic analysis of the TCS and TRD complete, formal documentation in work. Acoustic analysis of the TOF, RICH, and Tracker in work. Full VC acoustic test currently scheduled for February 2006.	
1.1.10 STATUS:	Open. Current testing requirements for each substructure defined in SVP. The ECAL did a sine sweep test to verify the first mode of the ECAL is 51.8 Hz. Documentation is still in work. The TOF, TRD, and TCS groups have dynamic tests scheduled. Other groups have provided FEM results demonstrating first modes well above the 50 Hz requirement.	
1.1.11 STATUS:	Closed. PAS Static Test Plan (LMSEAT 34105) reviewed and approved by ISS Structures and Mechanisms Team. IVT Test Preparation Sheet (BCP-S3-T037), PAS Test Report (53103), and IVT Test Report (53103A) provided to ISS Structures and Mechanisms Team for review.	
1.1.12 STATUS:	Open	
1.2 CONTROL:	SFHe tank feed through tubes are designed to physically isolate the Cryomagnet support system straps from bending, lateral or torsional loads. The Cryomagnet support system straps carry only axial loads.	
1.2.1 SVM:	Structural analysis will show that there is adequate clearance between the strap and the tube to prevent transfer of loads to the straps.	
1.2.1 STATUS:	Open. Adequate strap clearance demonstrated in latest DCLA. Clearance will continue to be monitored through the Verification Loads Analysis <a href="#">based on final measured static clearances</a> .	
1.3 CONTROL:	EVA Sites and translation paths have been assessed for compatibility with EVA contact loads, specifically EVA kick loads of 125 pounds. All structures that can be contacted have been assessed to have a positive margin considering a factor of safety of 2.0.	
1.3.1 SVM:	Structural Analysis	
1.3.1 STATUS:	Open	
1.4 CONTROL:	Structural joints that fail to attain a positive margin to the required factors of safety have been presented to the Structures Working Group and individually assessed for acceptability on the specific application and fracture acceptance rationale. The concern is that these joints can experience joint separation during the most severe loading conditions and while not yielding or losing structural integrity, may experience excessive load cycles that impact the overall fracture control acceptability of the hardware. The AMS-02 will demonstrate to the Structures Working Group that the load cycles that these joints will experience will not pose a risk to the overall hardware integrity or load carrying capability. NOTE:	

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This control does not address structural members that have negative margins, only the interface of joints.		
1.4.1 SVM: Acceptance of all occurrences of negative margins (documented in Stress Report) on joints by the JSC Structures Working Group.		
1.4.1 STATUS: Open		
2. CAUSE: Improper Material Selection (including Stress Corrosion Cracking)		
2.1 CONTROL: AMS-02 materials will be selected to meet the requirements of MSFC-STD-3029. Materials with high resistance to stress corrosion cracking will be used where possible. Materials with moderate or low resistance to stress corrosion cracking have MUAs that have been/will be approved for each application. MUAs are attached to this hazard report.		
2.1.1 SVM: Stress Corrosion Evaluation of materials list and drawings.		
2.1.2 SVM: ES4/Material and Processes Branch Certification for materials usage.		
2.1.1 STATUS: Open		
2.1.2 STATUS: Open		
2.2 CONTROLS: Joints and junctions of dissimilar metals will be avoided and where they cannot be avoided the materials will be selected to reduce the potential for galvanic corrosion.		
2.2.1 SVM: Material Compatibility Assessment		
2.2.2 SVM: Approval of material use and MUAs by JSC ES4/Materials and Processes Branch		
2.2.1 STATUS: Open		
2.2.2 STATUS: Open		
3. CAUSE: Initiation or propagation of flaws or crack-like defects.		
3.1.1 CONTROL: The AMS-02 project will use JSC-25863A to implement the fracture control requirements of NASA-STD-5003 and SSP-30558C. See attached table for fracture classification of each structural element.		
3.1.1 SVM: Compliance with the fracture control requirements of NASA-STD-5003 and SSP-30558C will be verified by approval of fracture control summary by JSC ES4/Materials and Processes Branch.		
3.1.1 STATUS: Open		

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4. CAUSE: Use of counterfeit, substandard or inadequate fasteners.		
<p>4.1 CONTROL: All fasteners, including safety critical fasteners contained in components supplied by subcontractors, #8 (~3 mm) and larger are selected and tested in accordance with JSC 23642E.</p> <p>4.1.1 SVM: AMS-02 Chief Engineer will collect all Certification documentation (including documentation for safety critical fasteners contained in components supplied by subcontractors) to verify that lot testing has been performed by JSC personnel to verify compliance with strength and chemical composition requirements of JSC-23642E. Chief Engineer's Report on Completion will close action.</p> <p>4.1.1 STATUS: Open</p>		
<p>4.2 CONTROL: All hardware with that is capable of releasing a mass of 0.25 lbs. or larger due to fastener(s) failure will be attached with #8 or larger fasteners.</p> <p>4.2.1 SVM: Review of design by AMS-02 Project to ensure compliance.</p> <p>4.2.2 SVM: Inspection of as built design.</p> <p>4.2.1 STATUS: Open</p> <p>4.2.2 STATUS: Open</p>		
5. CAUSE: Loosening of safety critical fasteners.		
<p>5.1 CONTROL: Safety-critical fasteners, including safety critical fasteners contained in components supplied by subcontractors, inadvertent back-off will be prevented by the use of locking inserts/nuts, self-locking bolts, safety wire and fastener preload/torque.</p> <p>5.1.1 SVM: Certification documentation (including documentation for safety critical fasteners contained in components supplied by subcontractors) that appropriate back off prevention methods were used.</p> <p>5.1.1 STATUS: Open</p>		
<p>5.2 CONTROL: For applications where small fasteners are used that utilized chemical thread lock (e.g. "Loctite", "Vibratite") to prevent backout, fasteners will be contained within the structure of the AMS-02 or its subelements. This controls the potential release of mass while on the ISS truss.</p> <p>5.2.1 SVM: Review of Design</p>		

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5.2.1 STATUS: Open		
<p><b>5.3 CONTROL:</b> In limited applications small fasteners capable of being released and not contained by AMS-02 Structures or its subelements and too small to utilize approved backout prevention methodologies have implemented a potting/embedding of the fastener head within an epoxy compound to contain the fastener.</p> <p>5.3.1 SVM: Inspection of fastener potting/embedding. (Cumulative report will close this verification.)</p> <p>5.3.1 STATUS: Open</p>		
6. CAUSE: Loss of structural integrity of welds.		
<p>6.1 CONTROL: The welds will have positive margins of safety during all mission phases, for the factors of safety specified in Control 1.1.</p> <p>6.1.1 SVM: Structural Analysis demonstrating positive margin of safety</p> <p>6.1.1 STATUS: Open</p>		
<p>6.2 CONTROL: Welding Processes are controlled by implementation of the AMS-02 Weld Control Plans and Procedures.</p> <p>6.2.1 SVM: Review and approval of He Tank Weld Control Plan by ES4/Materials and Processes Branch.</p> <p>6.2.2 SVM: Review <u>and approval</u> of the Vacuum Case Welding <b>Procedure-Plan</b> by ES4/Materials and Processes Branch</p> <p>6.2.3 SVM: Welds will be inspected: Dye Penetrant, X-ray, and/or Ultrasound</p> <p>6.2.1 STATUS: <u>Closed. Confirmation of ES4 acceptance of Weld Plan Review by ESCG/D. Rybiki and ES4/G. Ecord transmitted by email from ES4/B. S. Files on November 20, 2006 to AMS-02 Chief Engineer Chris Tutt</u><b>Open</b>. <del>He Tank Weld Control Plan under review by ES4 Materials and Processes Branch.</del></p> <p>6.2.2 STATUS: <u>Closed. Confirmation of ES4 acceptance of Weld Plan Review by ESCG/D. Rybiki and ES4/G. Ecord transmitted by email from ES4/B. S. Files on November 20, 2006 to AMS-02 Chief Engineer Chris Tutt</u><b>Open</b></p> <p>6.2.3 STATUS: Open</p>		
7. CAUSE: Improper manufacture and/ or assembly.		
<p>7.1 CONTROL: Approved drawings and procedures, including tool control, will be used for manufacturing and assembly.</p> <p>7.1.1 SVM: Certification documentation will be provided to verify proper manufacturing/assembly of AMS-02</p>		

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hardware (including all composite materials).		
7.1.1 STATUS: Open		
8. CAUSE: Improper preload or creeping of the Cryomagnet support system straps.		
8.1 CONTROL: Cryomagnet support system straps will be preloaded prior to flight to provide a balanced support load for the Cryomagnet. Preload is established by compressing a Belleville washer stack on a freestanding jig prior to installation. Preload strain measurements are made in conjunction with the initial setup. After installation and prior to launch this strain measurement is made to confirm that preload has not been lost.		
8.1.1 SVM: Verify preload at time of installation		
8.1.2 SVM: Long term creep analysis to ensure that the Cryomagnet support system straps will not be out of tolerance for any flight regime or over the life of the payload.		
8.1.1 STATUS: Open		
8.1.2 STATUS: Closed. Jacobs Memorandum ESCG-4039-05-SP-DO-0003 dated 4 July, 2005		
9. CAUSE: Damage to composite structural components during manufacturing, assembly operations, ground handling, and/or ground transportation.		
9.1 CONTROL: Each supplier/developer of composite structures will provide special handling procedures and requirements which are developed into work instructions for manufacturing, assembly operations, ground handling and/or ground transportation. Quality assurance representatives oversee the implementation of these work instructions to protect the composite structures.		
9.1.1 SVM: QA review of procedures and certification of procedure completion.		
9.1.1 STATUS: Open		
10. CAUSE: Degradation of composite structural components by atomic oxygen.		
10.1 CONTROL: All composite structures are covered with thermal blankets, structures and/or coatings to assure non-metallic components are not in a direct line of sight of atomic oxygen.		
10.1.1 SVM: Review of design.		
10.1.2 SVM: Inspection of as built hardware.		

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10.1.1 STATUS: Closed. Design of all load bearing composite structures indicate no line of sight to atomic oxygen. Memorandum ESCG-4390-06-SP-MEMO-0005, "Composite Structural Elements," dated 13 March 2006, AMS-02 Chief Engineer Chris Tutt.		
10.1.2 STATUS: Open		
11. CAUSE: Improper Preload of PAS		
11.1 CONTROL: In order to establish the proper stiffness and preload of the AMS-02 when grappled by the ISS active PAS the AMS-02 is designed to have an adjustable configuration on the AMS-02 PAS element. The stiffness has been established to meet the requirement of SSP 57003		
11.1.1 SVM: Structural Analysis (for Stiffness)		
11.1.2 SVM: Interface testing on S3 Truss with AMS-02 Flight PAS.		
11.1.3 SVM: Inspection of Flight hardware to confirm proper configuration of adjustment prior to flight.		
11.1.1 STATUS: Closed. Jacobs Sverdrup Memo ESCG-4390-06-SP-MEMO-0001, "Mechanical Design of the Payload Attach System (PAS)", Dated 8 January, 2006 from AMS-02 Chief Engineer.		
11.1.2 STATUS: Closed. Memo ESCG-4390-05-SP-MEMO-0012, "Functional Testing of the Payload Attach System" dated 28 December 2005, from AMS-02 Chief Engineer Chris Tutt.		
11.1.3 STATUS: Open		
12. CAUSE: Reconfiguration of Mechanical Components		
12.1 CONTROL: The EVA release of the PAS mechanism is structurally capable of enduring Orbiter return loads with a positive margin of safety regardless of return configuration (fully reinstalled with preload release screws returned to hardstop configuration or disengaged).		
12.1.1 SVM: Structural Analysis		
12.1.1 STATUS: Open		
12.2 CONTROL: The EVA reconfigurable ROEU Interface support bracket hinge will be capable of supporting Orbiter return loads with a positive margin of safety even if only one of the two EVA operated pip pins are installed. Nominal procedures will install two pins.		
12.2.1 SVM: Structural Analysis		

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12.2.1 STATUS: Open		
Notes:		

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ACRONYMS	
1-D – one dimensional	MIT – Massachusetts Institute of Technology
ACC – Anticoincidence Counter	mm – Millimeter
AMICA - Astro Mapper for Instruments Check of Attitude	PAS – Payload Attach Site (ISS Component, e.g. Active PAS)
AMS-02 – Alpha Magnetic Spectrometer 02	PAS – Payload Attach System (AMS-02 component)
ASR -	PMT – Photomultiplier Tube
ATR -	Ops - Operations
CERN - <i>Conseil Européen pour la Recherche Nucléaire</i> (European Council for Nuclear Research)	QA – Quality Assurance
Comp – Compressive	RICH – Ring Imaging Cherenkov Counter
CSIST – Chung-shan Institute of Science and Technology	ROEU – Remotely Operated Electrical Umbilical
ECAL – Electromagnetic Calorimeter	SCL – Space Cryomagnetics Laboratory
EVA – Extravehicular Activity	SFHe – Superfluid Helium
FEM – Finite Element Method	Si – Silicon
FOS – Factor of Safety	STA – Structural Test Article
FS – Factor of Safety	SVM – Safety Verification Method
He – Helium	SVP – Structural Verification Plan
HV – High Voltage	SWG – Structures Working Group
Hz – Hertz	TCS – Thermal Control System
I/F – Interface	TOF – Time of Flight
in – inch	TRD – Transition Radiation Detector
INFN - <i>Istituto Nazionale di Fisica Nucleare</i>	ult – Ultimate

ACRONYMS	
ISATEC – Company Name	UPS – Uninterruptible Power Supply
ksi – thousand pounds per square inch	USS – Unique Support Structure
L – Launch	UTOF – Upper Time of Flight
lbf – pounds force	VC – Vacuum Case
lbs – Pounds	Xe – Xenon
LTOF – Lower Time of Flight	XPD – Generic Power Distribution Box (First letter changed to designate specific subsystem)

## AMS-02 Structural Margin Tables

Margin of Safety Summary for Transition Radiation Detector (TRD) Structure					
Item	Drawing number	Material and temper	Material allowable stress (ksi)	Max. applied stress (ksi)	Margin of Safety (ult) FS=2.0
<b>TRD Support</b>					
M structure	7075-T7351	62	7.8	2.96	Page 24 Note 1
Corner brackets	7075-T7351	57	22.1	0.29	Page 28, Note 1
Upper bracket	7075-T7351	60	9.1	2.29	Page 29, Note 1
<b>TRD Octagon</b>					
Octagon panels	ams1912i-3d-02 ams1912p	Carbon fiber skin Al. 5056 core 1/8 in cell	145.6	54.1	0.34
Octagon panel flanges	ams 02 1912p Detail U,V	Carbon fiber skin Al. 5056 core 1/8 in cell	115.9	-33.1	0.75
Upper flange reinforcement ring	ams 02 1996 f	T33 Thanax Fabric	115.9	-28.4	1.04
Upper cover	ams 02 1942f	Carbon fiber skin Al. 5056 3/16 cell	115.9	-26.6	1.17
Margin of Safety Summary for Transition Radiation Detector (TRD) Gas System Structure					
Item	Drawing number	Material and temper	Material allowable stress (ksi)	Max. applied stress (ksi)	Margin of Safety (ult) FS=2.0
Box S plate	7050-T7451	66.1	30.6	0.08	Page 21, Note 2
Xe tank bracket	6061-T6	42	4.6	1.4	Page 21 Note 2
Lower bracket	7050-T7451	66.1	12.2	1.7	Page 21, Note 2
Box C base plate	6061-T6	49.3	20.3	0.21	Page 15 Note 3
Valve bracket	6061-T6	49.3	13.2	0.86	Page 15 Note 3
Margin of safety Summary of AMS-02 Upper Time of Flight (UTOF)					
Item	Drawing number	Material and temper	Material allowable stress (ksi)	Max. applied stress (ksi)	Margin of Safety (ult) FS=2.0
Lower brackets	ams TOF 08-01-001 UT	7075-T7351	64	16.0	0.98
Extensions	ams TOF 08-01-008 UT	7075-T7351	64	16.1	0.98
Honeycomb skins	ams TOF 08-02-002 UT	2024-T81	62.9	18.3	0.72
Secondary Brackets	ams TOF 02-	7075-T7351	64	8.1	2.92

01-005 UT						
Sensor Boxes	ams TOF 09-001 UT	CFRP T300 fabric	X = 115.9 Y = 115.9 XY = 14.3	X=4.9 Y=7.4 XY=4.6	0.51	Page 58, Note 4 Margin of safety Note 5
Scintillators	ams TOF 01-01-01 UT	CFRP T 300 fabric	X = 115.9 Y = 115.9 XY = 14.3	X=1.23 Y=1.29 XY=0.84	7.33	Page 58, Note 4 Margin of safety Note 5
PMT Boxes supports	ams TOF 05-05-001 UT	CFRP T 300 fabric	X = 115.9 Y = 115.9 XY = 14.3	X=10.4 Y=9.75 XY=2.4	1.70	Page 58, Note 4 Margin of safety Note 5
Margin of Safety Summary of AMS-02 Lower Time of Flight (LTOF)						
Item	Drawing number	Material and temper	Material allowable stress (ksi)	Max. applied stress (ksi)	Margin of Safety (ult) FS=2.0	Comments
Beam A	ams TOF 04-01-001 LT	7075-T7351	64	30.6	0.05	Page 76 Note 6
Beam B	ams TOF 04-01-002 LT	7075-T7351	64	29.8	0.07	Page 76 Note 6
Corner beam	ams TOF 04-01-003 LT	7075-T7351	64	11.0	1.9	Page 76 Note 6
Upper bracket	ams TOF 04-01-021 LT	7075-T7351	64	10.7	1.98	Page 76 Note 6
Lower bracket	ams TOF 04-01-020 LT	7075-T7351	64	10.0	>2.0	Page 76 Note 6
Internal bracket	ams TOF 04-01-018 LT	7075-T7351	64	13.30	>2.0	Page 76 Note 6
Struts	ams TOF 04-01-01-001 LT	7075-T7351	64	14.60	1.18	Page 76 Note 6
Sensor Boxes Bracket	ams TOF 04-01-008 LT	7075-T7351	64	17.84	0.79	Page 76 Note 6
Sensor Boxes	ams TOF 02-001 LT	CFRP T300 Fabric	X = 115.8 Y = 115.8 XY = 14.3	X=-9.7 Y=9.8 XY=3.9	1.56	Page 77, Note 6 Margin of safety Note 7
Boxes/PMT Support	ams TOF 05-05-001 LT	CFRP T300 Fabric	X = 115.8 Y = 115.8 XY = 14.3	X=13.9 Y=- 17.4 XY=- 3.5	1.17	Page 77, Note 6 Margin of safety Note 7
Scintillator supports		CFRP T300 Fabric	X = 115.8 Y = 115.8 XY = 14.3	X=17.4 Y=30.5 XY=5.9	0.12	Page 77, Note 6 Margin of safety Note 7

### Margin of safety Summary of AMS-02 Ring Imaging Chernkov Counter (RICH)

Item	Drawing number	Material and temper	Material allowable stress (ksi)	Max. applied tensile stress (ksi)	Margin of Safety (ult) FS=2.0	Comments
<b>External Structure</b>						
Primary beam		7075-T7351	64	12.7	1.51	Page 47 Note 8
Secondary Internal beam		7075-T7351	64	14.2	1.26	Page 47 Note 8
<b>Internal Structure</b>						
Structural members	10-001	7075-T7351	64	9.0	>2.0	Page 47 Note 8
Structural members	20-002	6061-T6	39.5	13.3	0.48	Page 47 Note 8
Reflector Support	40-001	7075-T7351	64	8.20	>2.0	Page 47 Note 8
Reflector	00-008	CFRP BRYTE EX-1515	68.6 68.6 27.2	X=2.1 Y=1.9 XY=1.1	>2.0	Page 48, Note 8 Margin of safety Note 9

### Margin of Safety summary of AMS-02 Electro Magnetic Calorimeter (ECAL)

Item	Drawing number	Material and temper	Material allowable stress (ksi)	Max. applied stress (ksi)	Margin of Safety (ult) FS=1.4	Comments
Honeycomb Face plate	ECAL0-10-Je	2024-T4 (2A12-T4)	61	16.0	1.73	Page 27 Note 10
Honeycomb I frame	ECAL0-11-Je	2014-T6 (2A14-T6)	65.3	21.3	1.19	Page 27 Note 10
Side panels	ECAL0-20-Je ECAL0-30-Je	2014-T6 (2A14-T6)	65.3	21.9	1.13	Page 27 Note 10
Bracket	ECAL0-41-Je	7050-T7451	69.9	21.0	1.37	Page 27 Note 10
Support beam	ECAL0-42-Je	7050-T7451	69.9	41.2	0.21	Page 27 Note 10

### Margin of Safety Summary of AMS-02 Star Tracker

Item	Drawing number	Materials and temper	Material allowable stress (ksi)	Max. limit stress (Ksi)	M.S. (ult) FS=2.0	Comments
Upper bracket		CFRP M55J ACGLTM110	154	43	0.41	Page 13, Note 11
Lower bracket		CFRP M55J ACGLTM110	154	31.6	0.11	Page 13, Note 11
Baffle to M structure		7075-T7351	59	29.2	0.01	Page 11, Note 12

Margin of safety summary of AMS-02 Silicon Tracker Structure						
Item	Drawing number	Material and temper	Material allowable stress (ksi)	Max. applied tensile stress (ksi)	Margin of Safety (ult) FS=2.0	Comments
<b>Tracker Outer Planes</b>						
Sandwich facing	AMS II 154 A0 AMS II 155 A0	Carbon fiber M60 J Cyanate Ester	50.7	fx=0.536 fy=0.826 fxy=0.276	>2.0	Page 22 Note 13
Sandwich core	AMS II 154 A0 AMS II 155 A0	Hexcel Honeycomb 3/16 in. Al. 5056	0.11	0.004	16	Page 22 Note 13
<b>Tracker Inner Planes</b>						
Sandwich core		Hexcel Honeycomb 3/8 in Al. 5056	0.025	0.011	0.12	Page 27 Note 13
Sandwich facing		Carbon fiber M60 J Cyanate Ester	72.5	fx=4.06 fy=3.33 fxy=1.65	4.8	Page 27 Note 13
Insert ring core		Hexcel Honeycomb 3/16 in. Al. 5056	0.11	0.024	1.26	Page 27 Note 13
Tracker feet		Ti-6Al-4V	130	56.4	0.14	Page 5, Note 14
<b>Margin of Safety summary of AMS-02 Cryo Magnet</b>						
Item	Drawing Number	Material and temper	Material allowable stress (ksi)	Max. applied tensile stress (ksi)	Margin of Safety (ult) FS = 1.50	Comments
Race track End frame	SCD0825	6061-T6 (10 in) 1.8 K	53.7	29.4	0.22	Page 7, sect.1.1.1 Note 15
Dipole Island	SCD0810	6061-T6 (10 in) 1.8 K	53.7	29.0	0.23	Page 8,sect.1.1.2 c Note 15
Race track coils	SCD0841	6061-T6 (10 in) 1.8 K	53.7	19.6	0.83	Page 8,sect.1.1.2 b Note 15
Race track edge plate outer	SCD0851-4	2219-T851 (300 K)	60.9	27.6	0.47	Page 13,sect 1.1.5 a, max. tens stress preload warm, Note 15
Race track edge plate curved	SCD0851-3	6061-T6 (10 in) (300K)	36.9	21.6	0.14	Page 13,sect 1.1.5 b, max. tens stress preload warm, Note 15
Dipole edge Plate	SCD0812-01	6061-T6 (10 in) (300K)	36.9	22.5	0.10	Page 14,sect 1.1.5 c, max. tens stress preload warm, Note 15
Helium vessel Fx support pin	SCD0889-02	316 Hi proof stainless steel (4K)	232.1	143.6	0.08	Page 48, sect 4.1.d inertia loads, Note 15
Helium vessel Fy	SCD0910-01	316 Hi proof stainless	31.9	20.5	0.42 yield	Page 49, sect 4.2.A inertia loads, Note

bracket

support pin		steel (4K)			15	
Helium vessel Fz support pin	SCD0898-01	316 Hi proof stainless steel (4K)	232.1	130.7	0.18	Page 54, sect 4.4.C inertia loads, Note 15
<b>Margin of safety Summary of AMS-02 Helium tank</b>						
Item	Drawing number	Material and temper	Material allowable yield stress (ksi)	Max. applied yield stress (ksi)	Margin of Safety (ult) FS=2.0	Comments
Central Ring	SCD 0905-01	5083-H111 forging	32.6	28.2	0.05	Page 18 Note 16
Thru tube weld	SCD 0903-02	5083-H111 forging	25.89	23.4	0.01	Page 18 Note 16
Outer ring	SCD 0905-02,-03	5083-H321	25.52	17.7	0.31	Page 18 Note 16
Inner ring weld	SCD 0905-04,-05	5083-H321	25.52	20.3	0.14	Page 18 Note 16
Porous plug weld	SCD 0905-22	5083-H321	25.89	20.7	0.13	Page 18 Note 16
End dish weld	SCD 0906	5083-H321	25.52	14.0	0.66	Page 18 Note 16
<b>Margin of Safety of AMS-02 Cryo Magnet Suspension Straps</b>						
Item	Drawing Number	Material and temper	Material allowable stress (ksi)	Max. applied tensile stress (ksi)	Margin of Safety (ult) FS = 1.40	Comments
Race track end frame clevis	SCD0825	6061-T6 (10 in)	13.69	4.43	0.11	Page 7, Note 17 RTEF_C1W1_clevis
Race track end frame clevis pin	SCD 0678-02	316L Hi-Proof stainless steel	127.64	85.77	0.06	Page 13, Note 17 RTEF_C1W1_clevis
Carbon Band	SCD 0678-03	Carbon Fiber epoxy	275.65	117.7	0.67	Note 18
FGR Band	SCD 0678-12	FGR3 epoxy	261.07	59.3	2.14	Note 18
Glass Band	SCD 0678-11	S2 glass epoxy	217.56	61.2	1.53	Note 18
Glass Bod	SCD 0678-18	S2 glass epoxy	217.56	98.3	0.58	Note 18
<b>Margin of Safety of AMS-02 Anti Coincidence Counter (ACC)</b>						
Item	Drawing Number	Material and temper	Material allowable stress (ksi)	Max. applied stress (ksi)	Margin of Safety (ult) FS = 2.0	Comments
ACC Clamps	ams-02-03 1024	7075-T7351	67	25.8	0.09	Page 12, Note 19
ACC cylinder	ams-02 1626	CFRP T300/EP	211	0.074	>2.0	
ACC panels	ams-02 1771c	Bicron BC 414 Polyvinyl Toluene	4.5	0.22	>2.0	
Connector support	1812/60_	7075-T7351	67	10.15	>2.0	Page 17, Note 19

0004_I_VI						
ACC PMT support	1812/60_001_I_VI	7075-T7351	67	0.13	>2.0	
<b>Margin of safety summary of Zenith Radiator</b>						
Item	Drawing Number	Material and temper	Material allowable stress (ksi)	Max. applied tensile stress (ksi)	Margin of Safety (ult) FS =2.0	Comments
Radiator panels	AMS-01.10.10.000	Rohacell core 2024-T81 face sheets	0.275	0.05	0.04	Page 88, Note 20
3W interface bracket	AMS-01.00.00.002	7075-T7351	58.7	25.6	0.15	Page 88, Note 20
Interface Spokes	AMS-01.30.00.003	Carbon fiber	130.5	57.3	0.14	Page 88, Note 20
<b>Margin of safety Summary of Main and Tracker Radiator</b>						
Item	Drawing Number	Material and temper	Material allowable stress (ksi)	Max. applied tensile stress (ksi)	Margin of Safety (ult) FS =2.0	Comments
RAM Main radiator panel heat pipes	AMS-02.10.00.000	6063-T5	26.1	12.8	0.02	Page 50, Note 21
WAKE Main radiator panel heat pipes	AMS-02.20.00.000	6063-T5	26.1	9.7	0.35	Page 76, Note 21
WAKE Main radiator I/F bracket	AMS-02.00.00.002	2024-T81	64.9	21.7	0.49	Page 76, Note 21
RAM tracker radiator rod bracket 2	AMS-03.00.00.004	7075-T7351	58.9	19.3	0.52	Page 76, Note 21
Wake tracker radiator panel face sheet	AMS-03.10.00.000	2024-T81	61.9	21.4	0.45	Page 76, Note 21
<b>Margin of safety of AMS-02 Electronic Crates and Radiator Brackets</b>						
Item	Drawing Number	Material and temper	Material allowable stress (ksi)	Max. applied tensile stress (ksi)	Margin of Safety (ult) FS =2.0	Comments
XPD structure	24- AMS-120.AB.XY	7075-T7351	63.8	17.7	0.80	Page 100, Note 22
Crate structure	24- AMS-110.AB.XY	7075-T7351	63.8	25.1	0.27	Page 95, Note 22
XPD board stiffeners	24- AMS-121.03.XY	6061-T6	39.3	17.4	0.13	Page 104, Note 22
Links	24- AMS-	7075-T7351	63.8	21.3	0.50	Page 108, Note 22

	130.01.XY					
Top bracket	24- AMS-310.02.XY	7075-T7351	63.8	29.7	0.07	Page 89, Note 22
Mid bracket	24- AMS-320.02.XY	7075-T7351	53.6	25.5	0.05	Page 189, Note 22
Lower bracket	24- AMS-320.02.XY	7075-T7351	63.8	11.2	1.85	Page 93, Note 22

### Margin of safety Summary of High Voltage (HV) Bricks

Item	Drawing Number	Material and temper	Material allowable stress (ksi)	Max. applied tensile stress (ksi)	Margin of Safety (ult) FS = 2.0	Comments
<b>ECAL and RICH HV Bricks</b>						
Bracket	7075-T7351	63.8	14.7	1.17	Page 125, Note 23	
Frame	7075-T7351	59.2	11.8	1.5	Page 125, Note 23	
Cover	6061-T62	39.5	6.8	1.88	Page 125, Note 23	
Lateral walls	7075-T7351	63.8	23.8	0.34	Page 125, Note 23	
<b>TOF HV bricks</b>						
Frame	7075-T7351	63.8	11.6	1.75	Page 126, Note 23	
Cover	6061-T62	39.5	14.0	0.41	Page 126, Note 23	
Vertical Stand off	7075-T7351	63.8	11.9	1.68	Page 126, Note 23	

### Margin of safety Summary of AMS-02 Vacuum case components

Item	Drawing number	Material and temper	Material allowable stress (ksi)	Max. applied stress (ksi)	Margin of Safety (ult) FS=1.4	Comments
Outer Cylinder	SDG39135779	7050-T7452 Forging	66	18.9	1.32	Page 1.1.3.2-8 Note 26
Outer Cylinder flanges	SDG39135779	7050-T7452 Forging	66	33.6	0.29	Page 1.1.3.1-8 Note 26
Inner Cylinder	SDG39135782	2219-T852 Forging	60	36.3	0.13	Page 1.1.2-8 Note 26
Inner cylinder weld	SDG39135782	2219-T852 Forging	30.7	19.7	0.116	CDR stress 14-May-03
Conical flanges	SDG39135778	2219-T62	54	28.7	0.3	Page 1.1.1-4 Note 26
Upper Support rings	SDG39135784	7050-T7452 Forging	65	39.7	0.08	Page 1.1.4-8 Note 26
Lower Support rings	SEG39135785	7050-T7452 Forging	65	41.3	0.03	Page 1.1.4-9 Note 26

### Margin of safety Summary of AMS-02 USS-02 components

Item	Drawing number	Material and temper	Material allowable stress (ksi)	Max. applied tensile stress (ksi)	Margin of Safety (ult) FS=1.4	Comments
Sill Trunnion	SDG39135732	Custom 455 H1000	200	Bend. = 92.8 Axial = 1.97 Shear = 19.6	0.86	Sect. 2.1.5 Note 27

Keel Trunnion	SDG39135772	Custom 455 H1000	200	Bend. =102.7 Axial = 0.97 Shear = 26.75	0.62	Sect. 2.3.4	Note 27
Upper VC Joint	SDG39135727	7050-T7451 Plate	69	43.8	0.04	Page 1.2.1.15-9	Note 27
Lower VC Joint	SDG39135737	7050-T7451 Plate	66	26.8	0.69	Page 1.2.2.5-9	Note 27
Sill joint primary secondary	SDG39135730	7050-T7451 Plate	66	26.7	0.55	page.2.1.3-10	Note 27
Diagonal strut assy	SEG39135741	6061-T6511		19.1	0.42		Note 27
Lower center body joint	SDG39135759					Page 1.2.2.6-13	Note 27
Sill elbow joint	SDG39135760	7050-T7451 Plate	70	38.8	0.18	Page 1.2.1.5-6	Note 27
Keel block	SEG39135770	7050-T7451 Plate	71	43.5	0.07	Page 1.2.3.1-7	Note 27
Diagonal sill bracket	SEG39135740	7050-T7451 Plate	70	43.1	0.07	Page 1.2.1.2-4	Note 27
Sill bracket	SEG39135738	7050-T7451 Plate	70	32.6	0.41	Page 1.2.1.1-6	Note 27
Lower USS to Upper USS joint	SDG39135762	7050-T7451 Plate	70	30.8	0.45	Page 1.2.2.1-18	Note 27

### Margin of safety Summary of AMS-02 UPS

Item	Drawing number	Material and temper	Material allowable stress (ksi)	Max. applied stress (ksi)	Margin of Safety (ult) FS=2.0	Comments
UPS Box	7075-T7351		66.0	8.6	2.82	Page 23 Note24

### Margin of safety Summary of AMS-02 E-Crates

Item	Drawing number	Material and temper	Material allowable stress (ksi)	Max. applied stress (ksi)	Margin of Safety (ult) FS=2.0	Comments
Bottom plate	7075-T7351		62.9	13.5	1.336	Page 50, Note 25
Lateral wall	7075-T7351		62.9	8.9	2.53	Page 50, Note 25

NOTE:

- 1) Ref. Transition Radiaton Detector (TRD) , Structural Verification Document, Rev.2, 26 November 2004 041126\_TRD\_SV\_Rev.2
- 2) Ref. TRD Gas System Box S Mechanical structure AMS-02 , 5 May 2004, INFN Rome and MIT
- 3) Ref. TRD Box C Finite element analysis, MIT @CERN, June 11, 2004
- 4) Ref. Upper Time of Flight structural Analysis Report, RICSYS-CGS-013, iss.1 , 29 June 2004
- 5) Tsai-Hill equation shown in report Note 1, Page 38 . Margin of safety is (1/SF\*Failure Index)-1
- 6) Ref. Lower Time of flight (LTOF) structural Analysis Report, RICSYS-RP\_CGS-012 iss. 1, 29 June 2004
- 7) Tsai-Hill equation shown in report note 1, page 44. Margin of safety is (1/SF\*Failure index)-1.
- 8) Ref. RICH Structural Analysis report, RICSYS-RP-CGS-009,iss.1, 29 June 2004

- 9) Tsai-Hill equation shown in report (note 1) page 44. Margin of safety = (1/SF\*Failure index)-1  
10) Ref. Flight ECAL Stress analysis after weight saving, 7 April 2004  
11) Ref. AMS-02 AMICA Star Tracker Support Design, INFN Rome, 16 July 2004  
12) Ref. Baffle Support design, INFN Rome, April 2005  
13) Ref. AMS Silicon Tracker Support Plates Analysis Report Extension AMS-ANR-002, Contraves Space, 19 November 1999.  
14) Ref. AMS 02 Tracker Support Feet , Rev. 1 Structural Verification Document, ISATEC, 16 June 2004  
15) Reference summary of Structural Analysis of AMS-02 Super conducting Magnet, September 2003, issue 02  
16) Ref. Helium tank Strength assessment, July 24, 2003  
17) Ref. Cryomagnet Suspension Strap Analysis  
18) Ref. Space Cryomagnetics Ltd (SCL) analysis, 6 February 2002  
19) Ref. AMS-02 Anti Coincidence Counter Structural Verification Document, ISATEC, 9 July 2004  
20) Ref. Zenith Radiator Structural analysis Report, AMS-OHB-SAR-001, iss 3, Nov. 26, 2004  
21) Ref. Main and Tracker Radiator Structural analysis Report, AMS-OHB-SAR-003, iss 2, Rev. a, April. 4, 2005  
22) Ref. Main Radiator Structural analysis Report, AMS-02-RP-CGS-005, iss 3, November. 11, 2004  
23) Ref. HV Bricks Structural analysis Report, AMS-02-RP-CGS-007, iss 1, November. 22, 2004  
24) Ref. UPS Structural Analysis Report, CSIST Taiwan, May 27, 2005  
25) Ref. Report AMS-02 RP-CGS-003, issue 1, 26 February 2004, Carlo Gavazzi Space  
26) Ref. AMS-02, Vacuum Case Stress analysis report  
27) Ref. AMS-02, USS-02 Stress analysis report

## AMS-02 FASTNERS MARGIN TABLES

TRD Fasteners						
Item	Drawing number	Material and temper	Material allowable stress (ksi)	Applied Load (lbf)	Margin of Safety (ult) FS=2.0	Comments
Corner bracket to upper VC joint	SEG39135720	0.5-20, A286	180	Tension = 1551 Shear = 619	0.013	Total tension yield, Note 12
Upper bracket to M structure		1/4-28, A286	160	Tension = 1167 Shear = 0	0.02	Joint separation
Corner bracket to M structure		5/16-24, A286	200	Tension = 2656 Shear = 84	0.04	Joint separation
Upper brackets to upper cover		1/4-28, A286	140	Tension = 732 Shear = 0	0.02	Tension yield
Upper cover to octagon		5/16-24, A286	140	Tension = 801 Shear = 0	0.08	Tension yield
TRD Gas System Fasteners						
Item	Drawing number	Material and temper	Material allowable stress (ksi)	Applied Load (lbf)	Margin of Safety (ult) FS=2.0	Comments
Box S plate to USS upper I/F bolts	NAS1954 0.25-28 A-286	180	Tension = 148 Shear = 978	0.01	Tension yield, Note 1	
Box S Xe bracket to plate bolts	NAS1351N 0.375-24 A-286	160	Tension = 816 Shear = 698	0.01	Tension yield, Note 1	
Box C mounting of cylinder to bracket	NAS1351 0.164-32 A-286	80	Tension = 25 Shear = 73	2.0	Page 32 Note 2	
Box C mounting of valve bracket to holder	NAS1351 0.164-32 A-286	80	Tension = 44 Shear = 85	1.91	Page 39 Note 2	
AMS-02 Upper Time of Flight (UTOF) Fasteners						
Item	Drawing number	Material and temper	Material allowable stress (ksi)	Applied Load (lbf)	Margin of Safety (ult) FS=2.0	Comments
USS I/F bolts	Joint 1	A-286, 0.3125-24 EWB-0420-5	200	Tension = 2646 Shear = 0	0.10	Tension yield
Bracket extension bolts	Joint 3	A-286, NAS1351 0.25-28,	160	Tension = 465 Shear = 961	0.04	Combined tension and Shear
Upper to lower bolts	Joint 4	A-286, NAS1351 0.25-28	160	Tension = 337 Shear = 232	0.16	Tension yield
AMS-02 Lower Time of Flight (LTOF)Fasteners						
Item	Drawing number	Material and	Material	Applied Load (lbf)	Margin of	Comments

		temper	allowable stress (ksi)	Safety (ult) FS=2.0	
Bracket to ring bolts	Joint 1	A-286, NAS1351-5 0.3125-24	160	Axial = 633 Shear = 1179	0.01 Combined tension and Shear
USS to Upper bracket bolts	Joint 2	A-286, NAS1351-6 0.375-24	160	Axial = 2788 Shear = 107	0.03 Joint separation
USS to Lower bracket bolts	Joint 3	A-286, NAS1351-3 0.190-32	160	Axial = 108 Shear = 158	0.15 Tension yield
Ring to Honeycomb bolts	Joint 4	A-286, NAS1351-4 0.25-28	160	Axial = 130 Shear = 283	0.16 Tension yield
AMS-02 Ring Imaging Chernkov Counter (RICH) Fasteners					
Item	Drawing number	Material and temper	Material allowable stress (ksi)	Applied Load (lbf)	Margin of Safety (ult) FS=2.0
External Structure bolts	Joint 1	A-286, NAS1351N4 0.25-28	160	Tension = 84 Shear = 987	0.05 Combined tension and Shear
External to Internal structure bolts	Joint 2	A4-70 0.118-44 (3 mm)	116	Tension = 89 Shear = 61	0.10 Tension yield
External Structure bolts	Joint 3	A-286, NAS1351N5 0.3125-24	160	Tension = 132 Shear = 855	0.06 Combined tension and Shear
AMS-02 Electro Magnetic Calorimeter (ECAL) Fasteners					
Item	Drawing number	Material and temper	Material allowable stress (ksi)	Applied Load (lbf)	Margin of Safety (ult) FS=1.4
Support beam to bracket (Joint 1)	ECAL0-0E	A-286 0.3125-24 NAS 6705U7, 8	160	Tensile = 2728 Shear = 0.0	0.081 Total tension yield. Note 6
Bracket to side panels (joint 2)	ECAL0-0E	A-286 0.25-28 NAS 1954C6	180	Tensile = 3201 Shear = 264	0.041 Total tension yield, Note 6
I Frame to bracket bolts (joint 3)	ECAL0-0E	A-286 0.3125-24 NAS 6705HU10	160	Tensile = 358 Shear = 0.0	0.20 Total tension yield, Note 6
I Frame to honeycomb reinforcing and side panels 1 and 2 bolts (joint4)	ECAL0-0E	A-286 0.025-28 NAS1004-2	140	Tensile = 156 Shear = 1287	0.088 Combined tension and shear, Note 6
I Frame to side panel 1 bolts(Joint 5)	ECAL0-0E	A-286 0.25-28 NAS1004-9	140	Tensile = 93 Shear = 85	0.182 Total tension yield, Note 6
I-Frame to side panels	ECAL0-0E	A-286 0.3125-24	140	Tensile = 335	0.165 Total tension yield, Note 6

1 and 2 (joint 6)	NAS1005-1,-2	Shear = 563				
I-Frame to honeycomb reinforcing and side panels 1 and 2 (Joint 7)	ECAL0-0E	A-286 0.3125-24 NAS1005-1	140	Tensile = 887 Shear = 601	0.141	Total tension yield, Note 6
Support to USS (Joint 8)	ECAL0-0E	A-286 0.625-18	140	Tensile = 4389 Shear = 1270	0.171	Total Tension yield, Note 6
AMS-02 Star Tracker Fasteners						
Item	Drawing number	Material and temper	Material allowable stress (ksi)	Applied Load (lbf)	Margin of Safety (ult) FS=2.0	Comments
Upper bracket to tracker plane 1 bolts	A286, 0.39 (M10)	160	Tension = 67 Shear = 268	0.005	Total tension Yield, Note 3	
Upper bracket to lower bracket bolts	A286, 0.190	160	Tension = 125 Shear = 116	0.009	Total tension Yield , Note 3	
Lower bracket to tracker conical flange	A286, 0.118 (M3)	160	Tension = 8 Shear = 112	0.03	Total tension Yield, Note 3	
Baffle bracket Baffle side to Baffle bolts	A286 0.190-32	160	Tension = 38 Shear = 14	0.03	Total tension Yield, Note 4	
AMS-02 Silicon Tracker Structure Fasteners						
Item	Drawing number	Material and temper	Material allowable stress (ksi)	Applied Load (lbf)	Margin of Safety (ult) FS=2.0	Comments
Tracker feet to magnet (Joint1)	A4-70, 0.3125-24 UNF	101.5	Tension = 1072 Shear = 0	0.02	Joint separation	
Tracker feet to Tracker shell (Joint2)	A-286 10-32 UNF	200	Tension = 892 Shear = 0	0.05	Joint separation	
Conical Flange to tracker shell (Joint3)	A-286, M4x33	200	Tension = 327 Shear = 333	0.01	Combined tension and shear	
Tracker shell to tracker shell (Joint 4)	A4-70, 0.138-32 UNF	101.5	Tension = 59 Shear = 331	0.001	Combined tension and shear	
Inner plane to tracker shell (Joint 5)	A4-70, M4x12	101.5	Tension = 49 Shear = 60	0.182	Total tension yield	
Outer plane to conical flange (Joint 6)	A4-70, M4x40	101.5	Tension = 29 Shear = 80	0.159	Total thread shear ultimate	
Outer plane to conical flange (Joint 7)	A4-70, M4x40	101.5	Tension = 29 Shear = 80	0.049	Total thread shear ultimate	

Item	Drawing Number	Material and temper	Material allowable Load (lbf)	Applied Load (lbf)	Margin of Safety SF =2.0	Comments
RT1 to RT3 bolts	SCD0842-01	A4/70, M8 316 stainless steel	3702	2534	0.46 yield	Page 2, Appendix 5 Note 5
RT3 to RT5 bolts	SCD0845-04	A4/70, M12 316 stainless steel	8527	5666	0.50 yield	Page 2, Appendix 5 Note 5
RTEF to RT5 bolts	SCDXXX	M8, 316 Hi proof stainless steel	6129	2468	1.48 yield	Page 2, Appendix 5 Note 5
Dipole crossbeam to RTEF bolts	SCD0815	UNF 316 Hi proof stainless steel	17417	3758	3.63 yield	Page 2, Appendix 5 Note 5
Dipole island to RTEF bolts	SCD0824	M5, 316 Hi proof stainless steel	2378	1114	1.14 yield	Page 2, Appendix 5 Note 5
Dipole edge plate to RTEF bolts	SCD0824	M5, 316 Hi proof stainless steel	2378	1166	1.04 yield	Page 2, Appendix 5 Note 5
Helium vessel Fz support bolts	SCD0898	M8, 316 Hi proof stainless steel	6129	3313	0.85 yield	Page 2, Appendix 5 Note 5
Fasteners Anti Coincidence Counter (ACC)						
Item	Drawing number	Material and temper	Material allowable stress (ksi)	Applied Load (lbf)	Margin of Safety (ult) FS=2.0	Comments
ACC clamps to VC flange bolts	A-286 0.190-32	200	Tension = 545 Shear = 0	0.012	Tension yield	
Fasteners Zenith Radiator						
Item	Drawing number	Material and temper	Material allowable stress (ksi)	Applied Load (lbf)	Margin of Safety (ult) FS=2.0	Comments
Sandwich panel to 3w-IF bracket	Joint 0203	A286 0.190-32	160	tension = 44 Shear = 254	0.08	Joint separation
3w-IF bracket to TRD	Joint 0305	A286 0.25-28	160	tension = 601 Shear = 402	0.20	Joint separation
Z bracket to TRD upper plate	Joint 0405	A286 0.190-32	160	tension = 215 Shear = 148	0.19	Joint separation
Fasteners Main and Tracker Radiator						
Item	Drawing number	Material and temper	Material allowable stress (ksi)	Applied Load (lbf)	Margin of Safety (ult) FS=2.0	Comments
RAM main radiator to ASR I/F bracket	Joint 0103	A 286 0.190-32	160	Tension = 19 Shear = 112	0.53	Combined Tension and shear yield

Tracker radiator to ASR I/F bracket	Joint 0203	A 286 0.190-32	160	Tension = 12 Shear = 205	0.49	Combined Tension and shear yield
Tracker radiator panel to ATR rod bracket 3	Joint 0206	A 286 0.190-32	160	Tension = 0.0 Shear = 126	0.54	Combined Tension and shear yield
ATR rod bracket 2 to USS	Joint 0509	A 286 0.25-28	160	Tension = 0.0 Shear = 726	0.41	Combined tension and shear ultimate
Fasteners AMS-02 Electronic Crates and Radiator Brackets						
Item	Drawing number	Material and temper	Material allowable stress (ksi)	Applied Load (lbf)	Margin of Safety (ult) FS=2.0	Comments
USS to Bracket	Joint 1	A 286 0.25-28	160	Tension = 596 Shear = 345	0.13	Tension yield
Brackets to Electronic boxes upper	Joint 2	A 286 0.190-32	200	Tension = 496 Shear = 528	0.03	Combined tension and shear
Main radiator Joints	Joint 3 b	A 286 0.25-28	160	Tension = 65 Shear = 956	0.07	Combined tension and shear
Links to electronic boxes	Joint 4	A 286 0.190-32	160	Tension = 396 Shear = 239	0.11	Tension yield
Electronic boxes wall joints	Joint 5a	A 286 0.164-32	160	Tension = 87 Shear = 7	0.14	Tension yield
Electronic boxes wall joints/TPD	Joint 5b1	A 286 0.164-32	160	Tension = 903 Shear = 94	0.02	Combined tension and shear (negative MS on Joint separation)
Electronic boxes wall joints/upper T crate	Joint 5b2	A 286 0.190-32	160	Tension = 1036 Shear = 314	0.02	Tension yield (negative MS on Joint separation)
Fasteners ECAL and RICH HV Bricks						
Item	Drawing Number	Material and temper	Material allowable stress (ksi)	Applied Load (lbf)	Margin of Safety (ult) FS =2.0	Comments
HV Bricks to USS	Joint 1	A 286 0.25-28 NAS1351N4	160	Tension = 245 Shear = 202	0.18	Tension yield
Lateral wall to bracket	Joint 2	A4 80 0.0984 in (2.5 mm)	116	Tension = 8 Shear = 56	0.17	Tension yield
Frame and bracket	Joint 3	A 4 80 0.1181 in (3 mm)	116	Tension = 130 Shear = 114	0.09	Tension yield
Fasteners TOF HV bricks						
Item	Drawing Number	Material and temper	Material allowable stress (ksi)	Applied Load (lbf)	Margin of Safety (ult) FS =2.0	Comments
TOF HV bricks to	Joint 1	A 286 0.25-28	160	Tension = 152	0.16	Tension yield

Radiators						Shear = 131
Lateral wall to Frame	Joint 2	A4 80 0.0984 in (2.5 mm)	116	Tension = 26 Shear = 39	0.15	Tension yield
Vertical stand off to cover	Joint 3	A4 80 0.1181 (3 mm)	116	Tension = 109 Shear = 84	0.11	Tension yield
Fasteners AMS-02 Vacuum case components						
Item	Drawing number	Material and temper	Material allowable stress (ksi)	Applied Load (lbf)	Margin of Safety (ult) FS=1.4	Comments
Upper I/F plate to Vacuum case	SEG39135776	A 286 0.375-24	180	Tension = 2599 Shear = 774	0.102	Total tension yield, Note 8
Lower Support ring to conical flange	SEG39135776	EWB 0420 0.25-28	200	Tension = 560 Shear = 815	0.064	Total tension yield, Note 8
Lower Support ring to O/C flange	SEG39135776	EWB 0420 0.25-28	200	Tension = 881 Shear = 422	0.075	Total tension yield, Note 8
Lower I/F plate to vacuum case	SEG39135776	A 286, 0.375-24	180	Tension = 1377 Shear = 703	0.106	Total tension yield, Note 8
Lower I/F plate to vacuum case	SEG39135776	A 286, 0.50-20	180	Tension = 2605 Shear = 1852	0.103	Total tension yield, Note 8
Clevis plate to Upper support ring	SEG39135776	A 286 0.5-20	180	Tension = 5986 Shear = 5323	0.070	Total tension yield, Note 8
USS-02 Fasteners						
Item	Drawing number	Material and temper	Material allowable stress (ksi)	Applied Load (lbf)	Margin of Safety (ult) FS=1.4	Comments
Upper I/F plate to USS-02	SDG39135726	A 286 0.50-20	180	Tension = 3729 Shear = 1156	0.035	Total tension yield, Note 9
Lower I/F plate to USS-02	SDG39135726	A 286 0.50-20	180	Tension = 2280 Shear = 2852	0.054	Total tension yield, Note 9
Sill bracket to Sill joint	SFG38116959	A 286 0.50-20	180	Tension = 4528 Shear = 3500	0.070	Total tension yield, Note 9
Lower USS to Upper USS bolts	SFG38116959	A 286 0.50-20	180	Tension = 6363 Shear = 2995	0.027	Joint Separation, Note 9
Lower angle beam to centerbody box joint	SFG38116959	EWB0420 0.50-20	200	Tension = 9151 Shear = 27	0.017	Joint separation, Note 9
Keel and PAS Fasteners						
Item	Drawing number	Material and temper	Material allowable stress (ksi)	Applied Load (lbf)	Margin of Safety (ult) FS=1.4	Comments

Keel angle joint to lower USS assembly	SFG38116959	EWB0420 0.50-20	200	Tension = 2366 Shear = 215	0.062	Total thread shear, Note 10
Vertex bracket to PAS platform	SEG39135812	A 286 0.375-24	180	Tension = 178 Shear = 393	0.010	Total tension yield, Note 11
Rear bracket PAS platform	SEG39135812	EWB0420, 0.375-24	200	Tension = 1174 Shear = 3186	0.019	Combined Shear and tension ultimate, Note 11
Fasteners AMS-02 UPS						
Item	Drawing number	Material and temper	Material allowable stress (ksi)	Max. applied Load (lbf)	Margin of Safety (ult) FS=2.0	Comments
UPS box to bracket bolts		A-286 0.25-28	160	Tension = 117 Shear = 250	0.10	Total tension yield
Bracket to USS bolts		A-286 0.25-28	180	Tension = 141 Shear = 128	0.11	Total tension yield
Fasteners AMS-02 E-Crate						
Item	Drawing number	Material and temper	Material allowable stress (ksi)	Applied Load (lbf)	Margin of Safety (ult) FS=2.0	Comments
E-Crates to USS-02	Joint 1	A 286 0.190-32 NAS1351N3	160	Tension = 601 Shear = 124	0.09	Total tension yield, Note 7
Lateral walls to bottom plate	Joint 2	A 286 0.190-32 NAS1351N3	160	Tension = 272 Shear = 339	0.13	Total tension yield, Note 7
Lateral walls	Joint 3	A286 0.164-32 NAS1352N08	160	Tension = 196 Shear = 157	0.12	Total tension yield, Note 7

## NOTE:

- 1) Ref. Box S May\_2004\_Rev1\_doc, Appendix 2, 30 June 2005
- 2) Ref. TRD Box C Finite element analysis, MIT @CERN, June 11, 2004
- 3) Ref. ASTS\_July 2004\_Rev1.doc, Appendix 2, INFN Rome
- 4) Ref. Baffle report\_April 2005\_rev 1.doc, appendix 1, INFN Rome
- 5) Reference summary of Structural Analysis of AMS-02 Super conducting Magnet, September 2003, issue 02
- 6) Ref. Report ESCG-4450-05-STAN-DOC-0131, January 2006
- 7) Ref. E-Crate structural analysis Report, AMS-02-RP-CGS-003, iss 1, 26 February 2004
- 8) Ref. Vacuum case analysis report Sect.3.10
- 9) Ref. USS-02 analysis report Sect. 2.4.1 and 2.4.2
- 10) Ref. Keel analysis report Sect. 2.4.3
- 11) Ref. PAS analysis report Sect. 4.1.2

## Fracture Classification for TRD Structure

Item	Drawing number	Material and temper	Material allowable stress (ksi)	Max. applied tensile stress (ksi)	Ratio of applied limit stress to allowable stress	Margin of Safety (ult) FS=2.0	Fracture Classification	Rationale	Comments
<b>TRD Support</b>									
M structure		7075-T7351	62	7.8	0.13	2.96	Low risk	Note 2	Page 24, Note 4
Corner brackets		7075-T7351	57	22.1	0.39	0.29	Low risk	Note 2	Page 28, Note 4
Upper bracket		7075-T7351	60	9.1	0.15	2.29	Low risk	Note 2	Page 29, Note 4
<b>TRD Octagon</b>									
Octagon panels	ams1912i-3d-02 ams1912p	Carbon fiber skin Al. 5056 core 1/8 in. cell	145.6	54.1	0.37	0.34	Low risk	Note 6	Page 30, Note 4
Octagon panel flanges	ams 02 1912p Detail U,V	Carbon fiber skin Al. 5056 core 1/8 in. cell	115.9	13.6 (tension) - 33.1 (comp)	0.12	0.75	Low risk	Note 6	Page 30, Note 4 .MS based on Comp. stress
Upper bracket to M structure		A286, 1/4-28	160	Tension = 1049 Shear = 12	0.63	0.36	Fail-safe	Note 3	Joint Separation, Note 9
Corner bracket to M structure		A286, 5/16-24	200	Tension = 2921 Shear = 133	0.60	0.12	Fail-safe	Note 3	Total tension yield, Note 9
Upper brackets to upper cover		A286, 1/4-28	140	Tension = 807 Shear = 7	0.60	0.39	Fail-safe	Note 3	Joint Separation, Note 9
Upper cover to octagon		A286, 5/16-24	140	Tension = 218 Shear = 801	0.57	0.56	Fail-safe	Note 3	Shear ultimate, Note 9
Corner bracket to Upper VC joint		A286, 1/2-20	180	Tension = 1805 Shear = 403	0.68	0.03	Fail-safe	Note 3	Combined tension and shear, Note 9

## Fracture Classification of TRD Gas System structure

Item	Drawing number	Material and temper	Material allowable stress (ksi)	Max. applied tensile stress (ksi)	Ratio of applied limit stress to allowable stress	Margin of Safety (ult) FS=2.0	Fracture Classification	Rationale	Comments
<b>TRD Gas System Structures</b>									
Box S plate		7050-T7451	66	30.6	0.46	0.08	Low risk	Note 2	Page 21, Note 5
Xe tank bracket		6061-T6	42	4.6	0.20	1.40	Low risk	Note 2	Page 21, Note 5
Lower bracket		7050-T7451	66	12.3	0.18	1.7	Low risk	Note 2	Page 21, Note 5
Box C base plate		6061-T6	49.3	20.3	0.41	0.21	Low risk	Note 2	Page 15, Note 7
Valve bracket		6061-T6	49.3	13.2	0.27	0.86	Low risk	Note 2	Page 15, Note 7
<b>Fasteners</b>									
Item	Drawing number	Material and temper	Material allowable stress (ksi)	Applied Load (lbf)	Ratio of applied limit stress to allowable stress	Margin of Safety (ult) FS=1.0	Fracture Classification	Rationale	Comments
Box S plate to USS upper I/F bolts		NAS1954 0.25-28 A-286	180	Tension = 44 Shear = 1680	0.53	0.52	Fail-safe	Note 3	Combined tension and shear, Note 8
Box S Xe bracket to plate bolts		NAS1351N 0.375-24 A-286	160	Tension = 1461 Shear = 445	0.54	0.40	Fail-safe	Note 3	Combined tension and shear, Note 8
Box C mounting of cylinder to bracket		NAS1351 0.164-32 A-286	80	Tension = 25 Shear = 73	0.29	2.0	Fail-safe	Note 3	Page 32, Note 7
Box C mounting of valve bracket to holder		NAS1351 0.164-32 A-286	80	Tension = 44 Shear = 85	0.29	1.91	Fail-safe	Note 3	Page 33, Note 7

Notes: (TRD Structure and Gas System)

- 1) The components will be classified as per JSC25863A, August 1998 to comply with NASA-STD-5003, October 1996 and SSP 30558 Rev. B, June 1994.
- 2) The component will be classified as low risk as per section 5.1.L.1, 5.1.L.2.A and 5.1.L.2.B.3 of JSC 25863A and will be shown that the component possesses acceptable durability (Possesses acceptable resistance to crack growth)
- 3) The component will be classified as fail-safe as per section 5.1.c of JSC 25863A
- 4) Ref. Transition radiation detector (TRD) Structural Verification Document (SVD) Rev. 2, 26 November 2004, 041126\_TRD\_SV\_Rev. 2
- 5) Ref. TRD Gas Supply system, Box S mechanical Structure AMS-02, 10 May 2004
- 6) The component will be classified as low risk as per section 5.2 d of JSC25863A
- 7) Ref. Finite Element Analysis for Box-C of TRD Gas System, MIT@CERN, 11 June 2004
- 8) Ref.Box S May\_2004\_Rev1\_doc, appendix 2, 30 June 2005
- 9) Ref. Mathcad analysis files , 6/8/2005

## Fracture Classification of AMS-02 Upper Time of Flight (UTOF)

Item	Drawing number	Material and temper	Material allowable stress (ksi)	Max. applied tensile stress (ksi)	Ratio of applied limit stress to allowable stress	Margin of Safety (ult) FS=2.0	Fracture Classification	Rationale	Comments
Upper brackets	ams TOF 08-01-006 UT	7075-T7351	64	31.4	0.49	0.02	Low risk	Note 2	Page 57, Note 4
Lower brackets	ams TOF 08-01-001 UT	7075-T7351	64	16.0	0.25	0.98	Low risk	Note 2	Page 57, Note 4
Extensions	ams TOF 08-01-008 UT	7075-T7351	64	16.1	0.25	0.98	Low risk	Note 2	Page 57, Note 4
Honeycomb skins	ams TOF 08-02-002 UT	2024-T81	62.9	18.3	0.29	0.72	Low risk	Note 2	Page 57, Note 4
Secondary Brackets	ams TOF 02-01-005 UT	7075-T7351	64	8.1	0.12	2.92	Low risk	Note 2	Page 57, Note 4
Sensor Boxes	ams TOF 09-001 UT	CFRP T300 fabric	115.9 115.9 14.3	X=4.9 Y=7.4 XY=4.6	0.04 0.06 0.32	0.51	Low risk	Note 5	Page 58, Note 4, Margin of safety, Note 6
Scintillators	ams TOF 01-01-01 UT	CFRP T 300 fabric	115.9 115.9 14.3	X=1.23 Y=1.29 XY=0.84	0.01 0.01 0.06	7.33	Low risk	Note 5	Page 58, Note 4, Margin of safety, Note 6
PMT Box Supports	ams TOF 05-05-001 UT	CFRP T 300 fabric	115.9 115.9 14.3	X=10.4 Y=9.75 XY=2.4	0.09 0.08 0.17	1.7	Low risk	Note 5	Page 58, Note 4, Margin of safety, Note 6

### UTOF Fasteners

Item	Drawing number	Material and temper	Material allowable stress (ksi)	Applied Load (lbf)	Ratio of applied limit stress to allowable stress	Margin of Safety (ult) FS=1.0	Fracture Classification	Rationale	Comments
UTOF/TRD I/F bolts	Joint 1	EWB0420-5 0.3125-24	200	Tension = 5292 Shear = 0	0.78	0.11	Fail-safe	Note 3	Total thread shear Note 7
Bracket to Ext. bolts	Joint 3	A-286 0.25-28	160	Tension = 1091 shear = 1922	0.63	0.04	Fail-safe	Note 3	Combined tension and shear, Note 7
Upper to lower bracket bolts	Joint 4	A-286 0.25-28	160	Tension = 674 Shear = 1407	0.60	0.24	Fail-safe	Note 3	Combined tension and shear, Note 7

Notes:

- 1) The components will be classified as per JSC 25863 A, August 1998 to comply with NASA-STD-5003, October 1996 and SSP 30558 Rev. B, June 1994
- 2) The component will be classified as low risk as per section 5.1.L.1, 5.1.L.2.A and 5.1.L.2.B.3 of JSC 25863 A and will be shown that the component possesses acceptable durability (Possesses acceptable resistance to crack growth)
- 3) The component will be classified as fail-safe as per section 5.1 c of JSC 25863 A
- 4) Ref. Upper Time of Flight Structural Analysis Report, RICSYS-CGS-013, iss. 1 , 29 June 2004
- 5) The component will be classified as low risk per section 5.2 d of JSC 25863 A
- 6) Tsai\_Hill equation shown in report (Note 4) , page 38. Margin of safety is (1/FS\*Failure Index)-1
- 7) Ref. AMS-02 Bolt Analysis\_Update\_v4.(1), 8/4/2005

## Fracture Classification of AMS-02 Lower Time of Flight (LTOF)

Item	Drawing number	Material and temper	Material allowable stress (ksi)	Max. applied tensile stress (ksi)	Ratio of applied limit stress to allowable stress	Margin of Safety (ult) FS=2.0	Fracture Classification	Rationale	Comments
Beam A	ams TOF 04-01-001 LT	7075-T7351	64	30.6	0.48	0.05	Low risk	Note 2	Page 76, Note 4
Beam B	ams TOF 04-01-002 LT	7075-T7351	64	29.8	0.46	0.07	Low risk	Note 2	Page 76, Note 4
Corner beam	ams TOF 04-01-003 LT	7075-T7351	64	11.0	0.17	1.9	Low risk	Note 2	Page 76, Note 4
Upper bracket	ams TOF 04-01-021 LT	7075-T7351	64	10.7	0.17	1.98	Low risk	Note 2	Page 76, Note 4
Lower bracket	ams TOF 04-01-020 LT	7075-T7351	64	10.0	0.16	>2.0	Low risk	Note 2	Page 76, Note 4
Internal bracket	ams TOF 04-01-018 LT	7075-T7351	64	13.30	0.21	1.4	Low risk	Note 2	Page 76, Note 4
Struts	ams TOF 04-01-01-001 LT	7075-T7351	64	14.60	0.23	1.18	Low risk	Note 2	Page 76, Note 4
Sensor Boxes Bracket	ams TOF 04-01-008 LT	7075-T7351	64	17.84	0.28	0.79	Low risk	Note 2	Page 76, Note 4
Sensor Boxes	ams TOF 02-001 LT	CFRP T300 Fabric	115.9 115.9 14.3	X=-9.7 Y=9.8 XY=3.9	0.08 0.08 0.27	1.56	Low risk	Note 6	Page 77, Note 4 Margin of safety Note 5
Boxes/PMT Support	ams TOF 05-05-001 LT	CFRP T300 Fabric	115.9 115.9 14.3	X=13.9 Y=-17.4 XY=-3.5	0.12 0.15 .25	1.17	Low risk	Note 6	Page 77, Note 4, Margin of safety, Note 5
Scintillator supports		CFRP T300 Fabric	115.9 115.9 14.3	X=17.4 Y=30.5 XY=5.9	0.15 0.26 0.41	0.12	Low risk	Note 6	Page 77, Note 4, Margin of safety, Note 5

### Fasteners

Item	Drawing number	Material and temper	Material allowable stress (ksi)	Applied Load (lbf)	Ratio of applied limit stress to allowable stress	Margin of Safety (ult) FS=1.0	Fracture Classification	Rationale	Comments
Bracket to ring bolts	Joint 1	A-286 0.3125-24	160	Axial = 617 Shear = 1153	0.56	0.14	Fail-safe	Note 3	Combined tension and shear, Note 7
USS to U bracket bolts	Joint 2	A-286 0.375-24	160	Axial =1177 Shear = 383	0.58	0.16	Fail-safe	Note 3	Total thread shear ultimate, Note 7
USS to L bracket bolts	Joint 3	A-286 0.190-32	160	Axial = 116 Shear = 248	0.59	0.33	Fail-safe	Note 3	Total thread shear ultimate, Note 7
Ring to Honeycomb bolts	Joint 4	A-286 0.25-28	160	Axial = 47 Shear = 778	0.58	0.26	Fail-safe	Note 3	Total thread shear ultimate, Note 7

## Notes:

- 1) The components will be classified as per JSC 25863A, August 1998 to comply with NASA-STD-5003, October 1996 and SSP 30558 Rev. B, June 1994
- 2) The component will be classified as fail-safe as per section 5.1.L.1, 5.1.L.2.A and 5.1.L.2.B.3 of JSC 25863 A and will be shown that the component possesses acceptable durability (possesses acceptable resistance to crack growth)
- 3) The component will be classified as fail-safe as per section 5.1 c of JSC 25863 A
- 4) Ref. Lower Time of Flight (LTOF) Structural Analysis Report, RICSYS-RP-CGS-012 iss 1, 29 June 2004
- 5) Tsai-Hill equation shown in report (note 4), page 44. Margin of safety is (1/FS\*Failure index)-1
- 6) The component will be classified as low risk as per sect. 5.2 d of JSC 25863A.
- 7) Ref. AMS-02 Bolt Analysis\_Update\_v4.(1), 8/4/2005

### Fracture Classification of AMS-02 Ring Imaging Cherenkov Counter (RICH)

Item	Drawing number	Material and temper	Material allowable stress (ksi)	Max. applied tensile stress (ksi)	Ratio of applied limit stress to allowable stress	Margin of Safety (ult) FS=2.0	Fracture Classification	Rationale	Comments
<b>External Structure</b>									
Primary beam		7075-T7351	64	12.7	0.20	1.51	Low risk	Note 2	Page 47, Note 4
Secondary Internal beam		7075-T7351	64	14.2	0.22	1.26	Low risk	Note 2	Page 47, Note 4
<b>Internal Structure</b>									
Structural members	12-RICSYS- 10-001	7075-T7351	64	9.0	0.14	>2.0	Low risk	Note 2	Page 47, Note 4
Structural members	12-RICSYS- 20-002	6061-T6	39.5	13.3	0.34	0.48	Low risk	Note 2	Page 47, Note 4
Reflector Support	12-RICSYS- 40-001	7075-T7351	64	8.20	0.13	>2.0	Low risk	Note 2	Page 47, Note 4
Reflector	13-RICSYS- 00-008	CFRP BRYTE EX-1515	68.6, 68.6 27.2	X=2.1, Y=1.9 XY=1.1	0.03, 0.028, 0.04	>2.0	Low risk	Note 5	Page 48, Note 4, Margin of safety, Note 6
<b>Fasteners</b>									
Item	Drawing number	Material and temper	Material allowable stress (ksi)	Applied Load (lbf)	Ratio of applied limit stress to allowable stress	Margin of Safety (ult) FS=1.0	Fracture Classification	Rationale	Comments
Joint 1									
External Structure bolts		A-286, 0.25-28	160	Tension = 66 Shear = 946	0.58	0.44	Fail-safe	Note 3	Combined tension and shear, Note 7
Joint 2									
External to Internal structure bolts		A4-70 0.118-44 (3 mm)	101.5	Tension = 88 Shear = 60	0.55	0.70	Fail-safe	Note 3	Combined tension and shear, Note 7
Joint 3									
External Structure bolts		A-286 0.3125-24	160	Tension = 486 Shear = 728	0.59	0.10	Fail-safe	Note 3	Combined tension and shear, Note 7

## Notes:

- 1) The components will be classified as per JSC25863A, August 1998 to comply with NASA-STD-5003, October 1996 and SSP 30558 Rev. B, June 1994
- 2) The component will be classified as low risk as per section 5.1.L.1, 5.1.L.2.A and 5.1.L.2.B.3 of JSC 25863A and will be shown that the component possesses acceptable durability (Possesses acceptable resistance to crack growth)
- 3) The component will be classified as fail-safe as per section 5.1.c of JSC 25863A
- 4) Ref. RICH Structural Analysis report, RICSYS-RP-CGS-009, iss.1, 29 June 2004
- 5) The Component will be classified as low risk as per section 5.2 d of JSC 25863 A
- 6) Tsai-Hill equation shown in report (note 4) page 44. Margin of safety =  $(1/SF^*Failure\ index)-1$
- 7) Ref. AMS-02 Bolt Analysis\_Update\_v4.(1), 8/4/2005

**Fracture Classification of AMS-02 Electro Magnetic Calorimeter (ECAL)**

Item	Drawing number	Material and temper	Material allowable stress (ksi)	Max. applied tensile stress (ksi)	Ratio of applied limit stress to allowable stress	Margin of Safety (ult) FS=1.4	Fracture Classification	Rationale	Comments
Honeycomb Face plate	ECAL0-10-Je	2024-T4 (2A12-T4)	61	16.0	0.26	1.73	Low risk	Note 2	Page 27, Note 4
Honeycomb I frame	ECAL0-11-Je	2014-T6 (2A14-T6)	65.3	21.3	0.33	1.19	Low risk	Note 2	Page 27, Note 4
Side panels	ECAL0-20-Je ECAL0-30-Je	2014-T6 (2A14-T6)	65.3	21.9	0.34	1.13	Low risk	Note 2	Page 27, Note 4
Bracket	ECAL0-41-Je	7050-T7451	69.9	21.0	0.33	1.37	Low risk	Note 2	Page 27, Note 4
Support beam	ECAL0-42-Je	7050-T7451	69.9	41.2	0.48	0.21	Low risk	Note 2	Page 27, Note 4

**Fasteners**

Item	Drawing number	Material and temper	Material allowable stress (ksi)	Applied Load (lbf)	Ratio of applied limit stress to allowable stress	Margin of Safety (ult) FS=1.0	Fracture Classification	Rationale	Comments
Support beam to bracket (Joint 1)	ECAL0-0E	A-286 0.3125-24 NAS 6705U7, 8	160	Tensile = 2748 Shear = 0.0	0.65	0.453	Fail-safe	Note 3	Combined tension and shear, Note 5
Bracket to side panels (joint 2)	ECAL0-0E	A-286 0.25-28 NAS 1954C6	180	Tensile = 3504 Shear = 216	0.70	0.23	Fail-safe	Note 3	Total Thread shear, Note 5
I Frame to bracket bolts (joint 3)	ECAL0-0E	A-286 0.3125-24, NAS 6705HU10	160				Fail-safe	Note 6	Fail-safe by Engineering Judgment
I Frame to honeycomb reinforcing and	ECAL0-0E	A-286 0.0.25-28 NAS1004-2	140				Fail-safe	Note 6	Fail-safe by Engineering Judgment

side panels 1 and 2 bolts (joint4)								
I Frame to side panel 1 bolts(Joint 5)	ECAL0-0E	A-286 0.25-28 NAS1004-9	140				Fail-safe	Note 6
I-Frame to side panels 1 and 2 (joint 6)	ECAL0-0E	A-286 0.3125-24 NAS1005-1,-2	140				Fail-safe	Note 6
I-Frame to honeycomb reinforcing and side panels 1 and 2 (Joint 7)	ECAL0-0E	A-286 0.3125-24 NAS1005-1	140				Fail-safe	Note 6
Support to USS (Joint 8)	ECAL0-0E	A-286 0.625-18	140	Tensile = 3497 Shear = 4392	0.77	0.585	Fail-safe	Note 3

Notes:

- 1) The components will be classified as per JSC25863A, August 1998 to comply with NASA-STD-5003, October 1996 and SSP 30558 Rev. B, June 1994.
- 2) The component will be classified as low risk as per section 5.1.L.1, 5.1.L.2.A and 5.1.L.2.B.3 of JSC 25863A and will be shown that the component possesses acceptable durability (Possesses acceptable resistance to crack growth)
- 3) The component will be classified as fail-safe as per section 5.1.c of JSC 25863A
- 4) Flight ECAL Stress Analysis after weight savings, April 7, 2004
- 5) Ref. ECAL bolt analysis report ESCG-4450-05-STAN-DOC-0131, February 2006
- 6) The components will be classified as fail-safe by Engineering Judgment as per section 5.1.c of JSC25863A

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### Fracture Classification of the AMICA Star Tracker

Item	Drg. No.	Materials and temper	Material allowable stress (ksi)	Max. limit stress (Ksi)	Limit stress to allowable ratio	M.S. (ult) FS=2.0	Fracture Classification	Rationale	Comments
Upper bracket		CFRP M55J ACGLTM110	Xt=154 Yt= 2.465 S = 6.1	43	0.35	0.41	Low risk	Note 4	Page 13, Note 5 Margin of Safety , Note 9
Lower bracket		CFRP M55J ACGLTM110	Xt=154 Yt= 2.465 S = 6.1	31.6	0.45	0.11	Low risk	Note 4	Page 13, Note 5, Margin of Safety , Note 9
Baffle to M structure bracket		7075-T7351	59	29.2	0.49	0.01	Low risk	Note 2	Page 11, Note 6
<b>Fasteners</b>									
Item	Drawing number	Material and temper	Material allowable stress	Applied Load (lbf)	Ratio of applied limit stress to	Margin of Safety (ult)	Fracture Classification	Rationale	Comments

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			(ksi)		allowable stress	FS=1.0			
Upper bracket to tracker plane 1 bolts		A286, 0.3937 (M10)	160	Tension =103 Shear =498	0.37	0.27	Fail-safe	Note 3	Total Thread shear, Note 7
Upper bracket to lower bracket bolts		A286, 0.190-32	160	Tension =163 Shear =154	0.53	0.22	Fail- safe	Note 3	Total Thread shear, Note 7
Lower bracket to tracker conical flange		A286, 0.118 (M3)	160	Tension =15 Shear =163	0.57	0.61	Fail- safe	Note 3	Combined tension and shear , Note 7,
Baffle bracket baffle side to baffle bolts		A286, 0.190-32	160	Tension =32 Shear =13	0.52	0.23	Fail-safe	Note 3	Combined tension and shear, Note 8

Notes:

- 1) The components will classified as per JSC 25863A, August 1998 to comply with NASA-STD-5003, October 1996 and SSP30558 Rev.B, June 1994
- 2) The components will be classified as low risk as per sect. 5.1.L.1, 5.1.L.2.A and 5.1.L.2.B.3 of JSC 25863A and will be shown that the component possesses acceptable durability (Possesses acceptable resistance to crack growth)
- 3) The component will be classified as fail-safe as per sect 5.1.c of JSC 25863A
- 4) The components will be classified as low risk as per section 5.2 d of JSC 25863A
- 5) Ref. AMS-02 AMICA Star Tracker Support Design, INFN Rome, 16 July 2004
- 6) Ref. Baffle Support design, INFN Rome, April 2005
- 7) Ref. ASTS\_July2004\_Rev1.doc, Appendix 2\_ASTS.doc
- 8) Ref. Baffle\_April2005\_Rev1.doc, Appendix1\_Baffle.doc
- 9) Tsai-Hill equation shown in report (note 5) page 12. Margin of safety = (1/SF\*Failure index)-1

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### Fracture Classification of AMS-02 Silicon Tracker

Item	Drawing number	Material and temper	Material allowable stress (ksi)	Max. applied tensile stress (ksi)	Ratio of applied limit stress to allowable stress	Margin of Safety (ult) FS=2.0	Fracture Classification	Rationale	Comments
<b>Tracker Outer Planes</b>									
Sandwich facing	AMS II 154 A0 AMS II 155 A0	Carbon fiber M60 J Cyanate Ester	50.7	$f_x=0.536$ $f_y=0.826$ $f_{xy}=0.276$	-	>2.0	Low risk	Note 4	Page 22 ,,Note 5
Sandwich core	AMS II 154 A0 AMS II 155 A0	Hexcel Honeycomb 3/16 in. Al. 5056	0.11	0.004	0.03	16.0	Low risk	Note 4	Page 22, Note 5
Insert	AMS II 148 A4 AMS II 149 A4 AMS II 150 A4	7075-T7351	Tension = 457 lbf Shear = 963 lbf Moment = 119 in lbf	Tension 8.3 lbf Shear 33 lbf Moment 8.6 in lbf	-	5.0	Fail-safe	Note 3	Page 22, Note 5

<b>Tracker Inner Planes</b>									
Item	Drawing number	Material and temper	Material allowable stress (ksi)	Applied Load (lbf)	Ratio of applied limit stress to allowable stress	Margin of Safety (ult) FS=1.0	Fracture Classification	Rationale	Comments
Sandwich core		Hexcel Honeycomb 3/8 in Al. 5056	0.025	0.011	0.45	0.12	Low risk	Note 4	Page 27, Note 5
Sandwich facing		Carbon fiber M60 J Cyanate Ester	72.5	fx=4.06 fy=3.33 fxy=1.65	-	4.8	Low risk	Note 4	Page 27, Note 5
Insert ring core		Hexcel Honeycomb 3/16 in. Al. 5056	0.11	0.024	0.22	1.26	Low risk	Note 4	Page 27, Note 5
Bolts pull out from insert		Vetronite	719 lbf	129 lbf	0.18	1.78	Fail-safe	Note 3	Note 5
Tracker feet		Ti-6Al-4V	130	56.4	0.43	0.14	Fail-safe	Note 3	Page 5, Note 6
<b>Fasteners</b>									
Item	Drawing number	Material and temper	Material allowable stress (ksi)	Applied Load (lbf)	Ratio of applied limit stress to allowable stress	Margin of Safety (ult) FS=1.0	Fracture Classification	Rationale	Comments
Tracker feet to magnet (Joint1)		A4-70, 0.3125-24 UNF	101.5	Tension = 1203 Shear = 0.0	0.53	0.09	Fail-safe	Note 3	Joint separation, Note 7
Tracker feet to Tracker shell (Joint2)		A-286 10-32 UNF	200	Tension = 2107 Shear = 0.0	0.81	0.06	Fail-safe	Note 3	Total tension ultimate, Note 7
Conical Flange to tracker shell (Joint3)		A-286, M4x33	200	Tension = 327 Shear = 333			Fail-safe	Note 8	Fail-safe by Engineering Judgment
Tracker shell to tracker shell (Joint 4)		A4-70, 0.138-32 UNF	101.5	Tension = 59 Shear = 0.0			Fail-safe	Note 8	Fail-safe by Engineering Judgment
Inner plane to tracker shell (Joint 5)		A4-70, M4x12	101.5	Tension = 49 Shear = 60			Fail-safe	Note 8	Fail-safe by Engineering Judgment
Outer plane to conical flange (Joint 6)		A4-70, M4x40	101.5	Tension = 29 Shear = 80			Fail-safe	Note 8	Fail-safe by Engineering Judgment
Item	Drawing number	Material and temper	Material allowable stress (ksi)	Applied Load (lbf)	Ratio of applied limit stress to allowable ult. stress	Margin of Safety (ult) FS=1.0	Fracture Classification	Rationale	Comments
Outer plane to conical flange		A4-70, M4x40	101.5	Tension = 29 Shear = 80			Fail-safe	Note 8	Fail-safe by Engineering Judgment

(Joint 7)									
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## Notes:

- 1) The components will be classified as per JSC25863A, August 1998 to comply with NASA-STD-5003, October 1996 and SSP 30558 Rev. B, June 1994.
- 2) The component will be classified as low risk as per section 5.1.L.1, 5.1.L.2.A and 5.1.L.2.B.3 of JSC 25863A and will be shown that the component possesses acceptable durability (Possesses acceptable resistance to crack growth)
- 3) The component will be classified as fail-safe as per section 5.1.c of JSC 25863A
- 4) The component will be classified as low risk as per section 5.2d of JSC 25863A
- 5) Ref. AMS Silicon Tracker Support Plates Analysis Report Extension AMS-ANR-002, Contraves Space, 19 November 1999.
- 6) Ref. AMS 02 Tracker Support Feet , Rev. 1 Structural Verification Document, ISATEC, 16 June 2004
- 7) Tracker results+Fail-safe-5, 1/23/06
- 8) There are multiple fasteners in this joint and the fasteners are classified as fail-safe by Engineering Judgment as per 5.1.c of JSC 25863A

### Fracture Classification for AMS-02 Cryo Magnet

Item	Drawing Number	Material and temper	Material allowable stress (ksi)	Max. applied tensile stress (ksi)	Ratio of applied limit stress to allowable stress	Margin of Safety (ult) FS =1.50	Fracture Classification	Rationale	Comments
Race track End frame	SCD0825	6061-T6 (10 in)	53.7	29.4	0.55	0.22	Low risk	Note 2	Page 7, sect.1.1.1 Note 4
Dipole Island	SCD0810	6061-T6 (10 in)	53.7	29.0	0.54	0.23	Low risk	Note 2	Page 8, sect.1.1.2 c Note 4
Race track coils	SCD0841	6061-T6 (10 in)	53.7	19.6	0.37	0.83	Low risk	Note 2	Page 8,sect.1.1.2 b Note 4
Race track edge plate outer	SCD0851-4	2219-T851	60.9	27.6	0.45	0.47	Low risk	Note 2	Page 13, sect 1.1.5 a, max. tens stress preload warm, Note 4
Race track edge plate curved	SCD0851-3	6061-T6 (10 in)	53.7	21.6	0.40	0.14	Low risk	Note 2	Page 13, sect 1.1.5 b, max. tens stress preload warm, Note 4
Dipole edge Plate	SCD0812-01	6061-T6 (10 in)	53.7	22.5	0.42	0.10	Low risk	Note 2	Page 14, sect 1.1.5 c, max. tens stress preload warm, Note 4
Helium vessel Fx support pin	SCD0889-02	316 Hi proof stainless steel	232.1	143.6	0.62	0.08	Low risk	Note 2	Page 47, sect 4.1.d inertia loads, Note 4
Helium vessel Fy support pin	SCD0910-01	316 Hi proof stainless steel	31.9	20.5	0.64	0.42 yield	Low risk	Note 2	Page 49, sect 4.2.A inertia loads, Note 4
Helium vessel Fz support pin	SCD0898-01	316 Hi proof stainless steel	232.1	130.7	0.56	0.18	Low risk	Note 2	Page 54, sect 4.4.C inertia loads, Note 4

#### Fasteners

Item	Drawing Number	Material and temper	Material allowable Load (lbf)	Applied Load (lbf)	Ratio of applied limit load to allowable load	Margin of Safety FS =1.0	Fracture Classification	Rationale	Comments
RT1 to RT3 bolts	SCD0842-01	A4/70, M8 316	3702	2534	0.68	0.46 yield	Fail-safe	Note 3	Page 2, Appendix 5, Note

		stainless steel							4
RT3 to RT5 bolts	SCD0845-04	A4/70, M12 316 stainless steel	8527	5666	0.66	0.50 yield	Fail-safe	Note 3	Page 2, Appendix 5, Note 4
RTEF to RT5 bolts	SCDXXX	M8, 316 Hi proof stainless steel	6129	2468	0.40	1.48 yield	Fail-safe	Note 3	Page 2, Appendix 5, Note 4
Dipole crossbeam to RTEF bolts	SCD0815	UNF 316 Hi proof stainless steel	17417	3758	0.22	3.63 yield	Fail-safe	Note 3	Page 2, Appendix 5, Note 4
Dipole island to RTEF bolts	SCD0824	M5, 316 Hi proof stainless steel	2378	1114	0.47	1.14 yield	Fail-safe	Note 3	Page 2, Appendix 5, Note 4
Dipole edge plate to RTEF bolts	SCD0824	M5, 316 Hi proof stainless steel	2378	1166	0.49	1.04 yield	Fail-safe	Note 3	Page 2, Appendix 5, Note 4
Helium vessel Fz support bolts	SCD0898	M8, 316 Hi proof stainless steel	6129	3313	0.54	0.85 yield	Fail-safe	Note 3	Page 2, Appendix 5, Note 4

Notes:

- 1) The components will be classified as per JSC 25863A, August 1998 to comply with NASA-STD-5003, October 1996 and SSP 30558 Rev. B, June 1994
- 2) The component will be classified as low risk as per section 5.1.L.1, 5.1.L.2.A and 5.1.L.2.B.3 of JSC25863A, and will be shown that the component possesses acceptable durability(Possesses acceptable resistance to crack growth)
- 3) The component will be classified fail-safe as per section 5.1.c of JSC25853A
- 4) Reference summary of Structural Analysis of AMS-02 Super conducting Magnet, September 2003, issue 02

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### Fracture Classification of AMS-02 Helium Tank

Item	Drawing number	Material and temper	Material allowable yield stress (ksi)	Max. applied yield stress (ksi)	Ratio of applied stress to allowable stress	Margin of Safety (ult) FS=2.0	Fracture Classification	Rationale	Comments
Central Ring	SCD 0905-01	5083-H111 forging	32.6	28.2	0.86	0.05	Non Fracture critical	Note 2	Page 18, Note 3
Thru tube weld	SCD 0903-02	5083-H111 forging	25.89	23.4	0.90	0.01	Non Fracture critical	Note 2	Page 18, Note 3
Outer ring	SCD 0905-02,-03	5083-H321	25.52	17.7	0.69	0.31	Non Fracture critical	Note 2	Page18, Note 3
Inner ring weld	SCD 0905-04,-05	5083-H321	25.52	20.3	0.79	0.14	Non Fracture critical	Note 2	Page 18, Note 3
Porous plug weld	SCD 0905-22	5083-H321	25.89	20.7	0.80	0.13	Non Fracture critical	Note 2	Page18, Note 3
End dish weld	SCD 0906	5083-H321	25.52	14.0	0.55	0.66	Non fracture critical	Note 2	Page 18, Note 3

Notes:

- 1) The components will be classified as per JSC25863A, August 1998 to comply with NASA-STD-5003, October 1996 and SSP 30558 Rev. B, June 1994.
- 2) The component will be classified as non fracture critical (Leak-before burst) as per sect.5.1 d of JSC 25863 A
- 3) Ref. Helium tank strength assessment, July 24, 2003

## Fracture Classification for AMS-02 Cryo Magnet Suspension Straps

Item	Drawing Number	Material and temper	Material allowable stress (ksi)	Max. applied tensile stress (ksi)	Ratio of applied limit stress to allowable stress	Margin of Safety (ult) FS = 1.40	Fracture Classification	Rationale	Comments
Race track end frame clevis	SCD0825	6061-T6 (10 in)	13.69	4.43	0.32	0.11	Fracture critical	Note 2,3	Page 7, Note 5 RTEF_C1W1_clevis
Race track end frame clevis pin	SCD 0678-02	316L Hi-Proof stainless steel	127.64	85.77	0.67	0.06	Fracture critical	Note 2,3	Page 13, Note 5 RTEF_C1W1_clevis
Carbon Band	SCD 0678-03	Carbon Fiber epoxy	275.65	117.7	0.43	0.67	Fracture critical	Note 2,3	Note 4
FGR Band	SCD 0678-12	FGR3 epoxy	261.07	59.3	0.22	2.14	Fracture critical	Note 2,3	Note 4
Glass Band	SCD 0678-11	S2 glass epoxy	217.56	61.2	0.28	1.53	Fracture critical	Note 2,3	Note 4
Glass Bod	SCD 0678-18	S2 glass epoxy	217.56	98.3	0.45	0.58	Fracture critical	Note 2,3	Note 4

Notes:

- 1) The components will be classified as per JSC25863A, August 1998 to comply with NASA-STD-5003, October 1996 and SSP 30558 Rev. B, June 1994
- 2) The component is classified as fracture critical as per sect 5.2 and is shown acceptable by sect. 6.0 of JSC 25863A
- 3) The flight hardware will be tested to a minimum of 1.2 times limit load
- 4) Ref. Space Cryomagnetics Ltd (SCL) analysis, 6 February 2002
- 5) Ref. Cryomagnet Suspension Strap Analysis

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## Fracture Classification for AMS-02 Anti Coincidence Counter (ACC)

Item	Drawing Number	Material and temper	Material allowable stress (ksi)	Max. applied tensile stress (ksi)	Ratio of applied limit stress to allowable stress	Margin of Safety (ult) FS = 2.0	Fracture Classification	Rationale	Comments
ACC Clamps	ams-02-03 1024	7075-T7351	67	25.8	0.38	0.30	Low risk	Note 2	Page 12, Note 4
ACC cylinder	ams-02 1626	CFRP T300/EP	211	0.074	0.00034	>2.0	Contained	Note 5	
ACC panels	ams-02 1771c	Bicron BC 414 Polyvinyl Toluene	4.5	0.22	0.049	>2.0	Contained	Note 5	
Connector support	1812/60-0004_I_VI	7075-T7351	67	0.09	0.0001	>2.0	Low risk	Note 2	Page 17, Note 4
ACC PMT Support	1812/60-001_I_VI	7075-T7351	67	0.13	0.002	>2.0	Low risk	Note 2	Note 4

### Fasteners

Item	Drawing Number	Material and temper	Material allowable Load (ksi)	Applied Load (lbf)	Ratio of applied limit stress to allowable stress	Margin of Safety FS = 1.0	Fracture Classification	Rationale	Comments
ACC clamps to VC		A-286 0.190-32	200	Tension = 1091	0.81	0.06	Fail-safe	Note 3	Joint separation, Note 6

flange bolts				Shear = 0					
PMT support to Vacuum case		A-286 0.190-32	160	Tension = 246 Shear = 272	0.66	0.36	Fail-safe	Note 3	Combined tension and shear, note 7

Notes:

- 1) The components will be classified as per JSC25863A, August 1998 to comply with NASA-STD-5003, October 1996 and SSP 30558 Rev. B, June 1994
- 2) The component will be classified as low risk as per section 5.1.L.1, 5.1.L.2.A and 5.1.L.2.B.3 of JSC25863A, and will be shown that the component possesses acceptable durability(Possesses acceptable resistance to crack growth)
- 3) The component will be classified as fail-safe as per section 5.1.c of JSC 25863A
- 4) Ref. AMS-02 Anti Coincidence Counter Structural Verification Document, ISATEC, 9 July 2004
- 5) The component is classified as contained as per sect. 5.1 g of JSC 25863A
- 6) ACC- clamps Mathcad analysis 7/15/2005
- 7) PMT-Support Mathcad analysis 7/15/2005

### Fracture Classification for Zenith Radiator

Item	Drawing Number	Material and temper	Material allowable stress (ksi)	Max. applied tensile stress (ksi)	Ratio of applied limit stress to allowable stress	Margin of Safety (ult) FS =2.0	Fracture Classification	Rationale	Comments
Radiator panels	AMS-01.10. 10.000	Rohacell core 2024-T81 face sheets	0.275	0.05	0.18	0.04	Low risk	Note 5	Page 88, Note 4
3W interface bracket	AMS-01.00. 00.002	7075-T7351	58.7	25.6	0.43	0.15	Low risk	Note 2	Page 88, Note 4
Interface Spokes	AMS-01.30. 00.003	Carbon fiber	130.5	57.3	0.44	0.14	Low risk	Note 5	Page 88, Note 4

### Fasteners

Item	Drawing Number	Material and temper	Material allowable Load (ksi)	Applied Load (lbf)	Ratio of applied limit stress to allowable stress	Margin of Safety FS =1.0	Fracture Classification	Rationale	Comments
Sandwich panel to 3w-IF bracket	Joint 0203	A286 0.190-32	160	tension = 28 shear = 300	0.58	0.45	fail-safe	Note 3	Page 88, Note 4
3w-IF bracket to TRD	Joint 0305	A286 0.25-28	160	tension 509 shear = 581	0.54	0.42	fail-safe	Note 3	Page 88, Note 4
Z bracket to TRD upper plate	Joint 0405	A286 0.190-32	160	tension=227 shear = 161	0.58	0.56	fail-safe	Note 3	Page 88, Note 4

Notes:

- 1) The components will be classified as per JSC25863A, August 1998 to comply with NASA-STD-5003, October 1996 and SSP 30558 Rev. B, June 1994
- 2) The component will be classified as low risk as per section 5.1.L.1, 5.1.L.2.A and 5.1.L.2.B.3 of JSC25863A, and will be shown that the component possesses acceptable durability( Possesses acceptable resistance to crack growth)
- 3) The component will be classified as fail-safe as per section 5.1.c of JSC 25863A
- 4) Ref. Zenith Radiator Structural analysis Report, AMS-OHB-SAR-001, issue 4, April 1,2005
- 5) The component will be classified as low risk as per section 5.2 d of JSC 25863A

## Fracture Classification for Main and Tracker Radiator

Item	Drawing Number	Material and temper	Material allowable stress (ksi)	Max. applied tensile stress (ksi)	Ratio of applied limit stress to allowable ult. stress	Margin of Safety (ult) FS. =2.0	Fracture Classification	Rationale	Comments
RAM Main radiator panel heat pipes	AMS-02.10 00.000	6063-T5	26.1	12.8	0.49	0.02	Low risk	Note 2	Page 50, Note 4
WAKE Main radiator panel heat pipes	AMS-02.20 00.000	6063-T5	26.1	9.7	0.35	0.35	Low risk	Note 2	Page 76, Note 4
WAKE Main radiator I/F bracket	AMS-02.00 00.002	2024-T81	64.9	21.7	0.33	0.49	Low risk	Note 2	Page 76, Note 4
RAM tracker radiator rod bracket 2	AMS-03.00 00.004	7075-T7351	58.9	19.3	0.33	0.52	Low risk	Note 2	Page 76, Note 4
WAKE tracker radiator panel face sheet	AMS-03.10 00.000	2024-T81	61.9	21.4	0.34	0.45	Low risk	Note 2	Page 76, Note 4
<b>Fasteners</b>									
Item	Drawing Number	Material and temper	Material allowable Load (ksi)	Applied Load (lbf)	Ratio of applied limit stress to allowable stress	Margin of Safety FS =1.0	Fracture Classification	Rationale	Comments
RAM main radiator to ASR I/F bracket	Joint 0103	A 286 0.190-32	160	Tension = 19 Shear = 131	0.55	0.74	fail-safe	Note 3	Page 68, 116, Note 4
Tracker radiator to ASR I/F bracket	Joint 0203	A 286 0.190-32	160	Tension = 19 Shear = 205	0.55	0.64	fail-safe	Note 3	Page 69, 116, Note 4
Tracker radiator panel to ATR rod bracket 3	Joint 0206	A 286 0.190-32	160	Tension = 18 Shear = 126	0.55	0.74	fail-safe	Note 3	Page 70, 116, Note 4
ATR rod bracket 2 to USS	Joint 0509	A 286 0.25-28	160	Tension = 91 Shear = 896	0.52	0.27	fail- safe	Note 3	Page 74, 117, Note 4

Notes:

- 1) The components will be classified as per JSC25863A, August 1998 to comply with NASA-STD-5003, October 1996 and SSP 30558 Rev. B, June 1994
- 2) The component will be classified as low risk as per section 5.1.L.1, 5.1.L.2.A and 5.1.L.2.B.3 of JSC25863A, and will be shown that the component possesses acceptable durability(Possesses acceptable resistance to crack growth)
- 3) The component will be classified as fail-safe as per section 5.1.c of JSC 25863A
- 4) Ref. Main and Tracker Radiator Structural analysis Report, AMS-OHB-SAR-003, issue. 2, Rev. A, April. 4, 2005

## Fracture Classification for Electronic Crates and Radiator Brackets

Item	Drawing	Material and	Material	Max. applied	Ratio of applied	Margin of	Fracture	Rationale	Comments
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	Number	temper	allowable stress (ksi)	tensile stress (ksi)	limit stress to allowable stress	Safety (ult) FS =2.0	Classification		
XPD structure	24- AMS-120.AB.XY	7075-T7351	63.8	17.7	0.28	0.80	Low risk	Note 2	Page 100, Note 4
Crate structure	24- AMS-110.AB.XY	7075-T7351	63.8	25.1	0.39	0.27	Low risk	Note 2	Page 95, Note 4
XPD board stiffeners	24- AMS-121.03.XY	6061-T6	39.3	17.4	0.44	0.13	Low risk	Note 2	Page 104, Note 4
Links	24- AMS-130.01.XY	7075-T7351	63.8	21.3	0.33	0.50	Low risk	Note 2	Page 108, Note 4
Top bracket	24- AMS-310.02.XY	7075-T7351	63.8	29.7	0.46	0.07	Low risk	Note 2	Page 89, Note 4
Mid bracket	24- AMS-320.02.XY	7075-T7351	63.8	27.2	0.43	0.17	Low risk	Note 2	Page 91, Note 4
Lower bracket	24- AMS-320.02.XY	7075-T7351	63.8	11.2	0.18	1.85	Low risk	Note 2	Page 93, Note 4

**Fasteners**

Item	Drawing Number	Material and temper	Material allowable stress (ksi)	Applied Load (lbf)	Ratio of applied limit stress to allowable stress	Margin of Safety FS =1.0	Fracture Classification	Rationale	Comments
USS to Bracket	Joint 1	A 286 0.25-28	160	Tension = 411 Shear = 722	0.59	0.24	fail-safe	Note 3	Total Thread shear ultimate, Note 5
Brackets to Electronic boxes/upper	Joint 2a1	A 286 0.190-32	200	Tension =176 Shear = 1067	0.70	0.04	fail-safe	Note 3	Combined tension and shear, Note 5
Main radiator Joints/T crate TPD	Joint 3b	A 286 0.250-28	160	Tension = 25 Shear = 892	0.58	0.26	fail-safe	Note 3	Total Thread shear ultimate, Note 5
Links to electronic boxes	Joint 4	A 286 0.190-32	160	Tension = 110 Shear = 367	0.59	0.34	fail- safe	Note 3	Total Thread shear ultimate, Note 5
Electronic boxes wall joints/TPD	Joint 5b1	A 286 0.164-32	160	Tension = 780 Shear = 395	0.62	0.32	fail-safe	Note 3	Combined tension and shear, Note 5
Electronic boxes wall joints/upper T crate	Joint 5b2	A 286 0.190-32	160	Tension = 780 Shear = 395	0.63	0.38	fail-safe	Note 3	Combined tension and shear, Note 5

Notes:

- 1) The components will be classified as per JSC25863A, August 1998 to comply with NASA-STD-5003, October 1996 and SSP 30558 Rev. B, June 1994
- 2) The component will be classified as low risk as per section 5.1.L.1, 5.1.L.2.A and 5.1.L.2.B.3 of JSC25863A, and will be shown that the component possesses acceptable durability(Possesses acceptable resistance to crack growth)
- 3) The component will be classified as fail-safe as per section 5.1.c of JSC 25863A
- 4) Ref. Main Radiator Structural analysis Report, AMS-02-RP-CGS-005, issue 3, November. 11, 2004
- 5) Ref. AMS-02 Bolt Analysis\_Update\_v4.(1), 8/4/2005

## Fracture Classification for High Voltage (HV) Bricks

Item	Drawing Number	Material and temper	Material allowable stress (ksi)	Max. applied tensile stress (ksi)	Ratio of applied limit stress to allowable stress	Margin of Safety (ult) FS =2.0	Fracture Classification	Rationale	Comments
<b>ECAL and RICH HV Bricks</b>									
Bracket		7075-T7351	63.8	14.7	0.23	1.17	Low risk	Note 2	Page 125, Note 4
Frame		7075-T7351	59.2	11.8	0.20	1.5	Low risk	Note 2	Page 125, Note 4
Cover		6061-T62	39.5	6.8	0.17	1.88	Low risk	Note 2	Page 125, Note 4
Lateral walls		7075-T7351	63.8	23.8	0.37	0.34	Low risk	Note 2	Page 125, Note 4
<b>TOF HV bricks</b>									
Frame		7075-T7351	63.8	11.6	0.18	1.75	Low risk	Note 2	Page 126, Note 4
Cover		6061-T62	39.5	14.0	0.35	0.41	Low risk	Note 2	Page 126, Note 4
Vertical Stand off		7075-T7351	63.8	11.9	0.19	1.68	Low risk	Note 2	Page 126, Note 4
<b>Fasteners</b>									
Item	Drawing Number	Material and temper	Material allowable stress (ksi)	Applied Load (lbf)	Ratio of applied limit stress to allowable stress	Margin of Safety FS =1.0	Fracture Classification	Rationale	Comments
<b>ECAL and RICH HV Bricks</b>									
HV Bricks to USS	Joint 1	A 286 0.25-28	160	Tension = 444 Shear = 258	0.58	0.56	fail-safe	Note 3	Combined tension and shear, Note 5
Lateral wall to bracket	Joint 2	A4 80 0.0984 in (2.5 mm)	116	Tension = 12 Shear = 107	0.62	0.42	fail-safe	Note 3	Combined tension and shear, Note 5
Frame and bracket	Joint 3	A 4 80 0.1181 in (3 mm)	116	Tension = 271 Shear = 219	0.71	0.21	fail-safe	Note 3	Combined tension and shear, Note 5
<b>TOF HV Bricks</b>									
TOF HV bricks to Radiators	Joint 1	A 286 0.25-28	160	Tension = 141 Shear = 134	0.59	0.25	fail- safe	Note 3	Total thread shear ultimate, Note 5
Lateral wall to Frame	Joint 2	A4 80 0.0984 in (2.5 mm)	116	Tension = 38 Shear = 33	0.62	0.53	fail-safe	Note 3	Combined tension and shear, Note 5
Vertical stand off to cover	Joint 3	A4 80 0.1181 (3 mm)	116	Tension = 153 Shear = 99	0.68	0.44	fail-safe	Note 3	Combined tension and shear, Note 5

Notes:

- 1) The components will be classified as per JSC25863A, August 1998 to comply with NASA-STD-5003, October 1996 and SSP 30558 Rev. B, June 1994
- 2) The component will be classified as low risk as per section 5.1.L.1, 5.1.L.2.A and 5.1.L.2.B.3 of JSC25863A, and will be shown that the component possesses acceptable durability(Possesses acceptable resistance to crack growth)
- 3) The component will be classified as fail-safe as per section 5.1.c of JSC 25863A
- 4) Ref. HV Bricks Structural analysis Report, AMS-02-RP-CGS-007, issue 1, November. 22, 2004

5) Ref. AMS-02 Bolt Analysis\_Update\_v4.(1), 8/4/2005

Fracture Classification of Vacuum Case Components									
Item	Drawing number	Material and temper	Material allowable stress (ksi)	Max. applied tensile stress (ksi)	Ratio of applied limit stress to allowable stress	Margin of Safety (ult) FS=1.4	Fracture Classification	Rationale	Comments
Outer Cylinder	SDG39135779	7050-T7452 Forging	66	18.9	0.28	1.32	Low risk	Note 2	Sect 3.2.1, Note 4
Outer Cylinder flanges	SDG39135779	7050-T7452 Forging	66	33.6	0.51	0.29	Low risk	Note 2	Sect 3.2.1, Note 4
Inner Cylinder	SDG39135782	2219-T852 Forging	60	36.3	0.60	0.13	Low risk	Note 2	Sect. 3.3.1, Note 4
Inner cylinder weld	SDG39135782	2219-T852 Forging	30.7	19.7	0.64	0.116	Fracture critical	Note 5	CDR stress 14-May-03
Conical Flanges	SDG39135778	2219-T62 Plate	54	28.7	0.53	0.3	Low risk	Note 2	Sect.3.3.1, Note 4
Upper Support rings	SDG39135784	7050-T7452 Forging	65	39.7	0.61	0.08	Low risk	Note 2	Sect. 3.4, Note 4
Lower Support Rings	SEG39135785	7050-T7452 Forging	65	41.3	0.63	0.03	Low risk	Note 2	Sect. 3.5, Note 4
Fasteners									
Item	Drawing Number	Material and temper	Material allowable Load (ksi)	Applied Load (lbf)	Ratio of applied limit stress to allowable stress	Margin of Safety FS =1.0	Fracture Classification	Rationale	Comments
Upper I/F plate to Vacuum case	SEG39135776	A 286 0.375-24	180	Tension = 2598 Shear = 605	0.59	0.495	Fail-safe	Note 3	Combined tension and shear ult, sect. 3.10.6 Note 4
Lower Support ring to conical flange	SEG39135776	EWB 0.25-28	200	Tension = Shear =			Fail-safe	Note 3	In work, Note 4
Lower Support ring to outer cylinder	SEG39135776	EWB 0.25-28	200	Tension = Shear =			Fail-safe	Note 3	In work, Note 4
Lower I/F plate to vacuum case	SEG39135776	A 286 .050-20	180	Tension =3124 Shear = 1347	0.59	0.475	Fail-safe	Note 3	Total thread shear ult, sect.3.10.7.2, Note 4
Lower I/F plate to vacuum case	SEG39135776	A 286 ,0.375-24	180	Tension =852 Shear = 1644	0.58	0.497	Fail-safe	Note 3	Combined tension and shear ultimate, sect.3.10.7.1, Note 4
Clevis plate to upper support ring	SEG39135776	A 286 0.50-20	180	Tension = 6380 Shear = 6387	0.64	0.285	Fail-safe	Note 3	Combined tension and shear ultimate, sect 3.10.5, Note 4

Notes:

1) The components will be classified as per JSC25863A, August 1998 to comply with NASA-STD-5003, October 1996 and SSP 30558 Rev. B, June 1994.

- 2) The component will be classified as low risk as per section 5.1.L.1, 5.1.L.2.A and 5.1.L.2.B.3 of JSC 25863 A and will be shown that the component possesses acceptable durability (Possesses acceptable resistance to crack growth)
- 3) The component will be classified as fail-safe as per section 5.1.c of JSC 25863A
- 4) AMS-02 Vacuum Case Stress analysis report
- 5) The component is classified as fracture critical as per sect. 5.2 and will be shown acceptable by compliance with sect. 6.0 of JSC 25863 A

### Fracture Classification of USS Components

Item	Drawing number	Material and temper	Material allowable stress (ksi)	Max. applied tensile stress (ksi)	Ratio of applied limit stress to allowable stress	Margin of Safety (ult) FS=1.4	Fracture Classification	Rationale	Comments
Sill Trunnion	SDG39135732	Custom 455 H1000	200	94.9	0.41	0.71	Fracture critical	Note 2	Sect. 2.1.5, Note 5
Keel Trunnion	SDG39135772	Custom 455 H1000	200	146.8	0.73	0.27	Fracture critical	Note 2	Sect. 2.3.4, Note 5
Upper VC Joint	SDG39135727	7050-T7451 Plate	69	43.8	0.63	0.04	Low risk	Note 3	Sect. 2.1.1, Note 5
Lower VC Joint	SDG39135737	7050-T7451 Plate	66	26.8	0.65	0.69	Low risk	Note 3	Sect. 2.1.9, Note 5
Sill joint primary secondary	SDG39135730	7050-T7451 Plate	66	26.7	0.40	0.63	Low risk	Note 3	Sect. 2.1.3, Note 5
Diagonal strut assy	SEG39135741	6061-T6511		19.1	0.50	0.42	Low risk	Note 3	Sect. 2.1.13, Note 5
Lower center body joint	SDG39135759 SDG39135760	7050-T7451 Plate	70	38.8	0.55	0.18	Low risk	Note 3	Sect. 2.2, Note 5
Sill elbow joint		7050-T7451 Plate	66	35.7	0.54	0.21	Low risk	Note 3	Note 5
Keel block	SEG39135770	7050-T7451 Plate	71	43.5	0.61	0.07	Fracture critical	Note 2	Sect. 2.3.2, Note 5
Diagonal sill bracket	SEG39135740	7050-T7451 Plate	70	43.1	0.61	0.07	Fracture critical	Note 2	Sect. 2.1.12, Note 5
Sill bracket	SEG39135738	7050-T7451 Plate	70	32.6	0.46	0.41	Low risk	Note 3	Sect. 2.1.10, Note 5
Lower USS to Upper USS joint	SDG39135762	7050-T7451 Plate	70	30.8	0.45	0.45	Low risk	Note 3	Sect. 2.2.4, Note 5

### Fasteners

Item	Drawing Number	Material and temper	Material allowable stress (ksi)	Applied Load (lbf)	Ratio of applied limit stress to allowable stress	Margin of Safety FS =1.0	Fracture Classification	Rationale	Comments
Upper I/F plate to USS-02	SDG39135726	A 286 0.50-20	180	Tension = 4163 Shear = 880	0.66	0.406	Fail-safe	Note 4	Combined tension and shear ultimate, Note 5
Lower I/F plate to USS-02	SEG39135726	A 286 0.50-20	180	Tension = 2055 Shear = 4484	0.65	0.37	Fail-safe	Note 4	Combined tension and shear ultimate, Note 5
Lower USS to Upper USS bolts	SEG39135724	A 286 0.50-20	180	Tension = 7467 Shear = 3285	0.68	0.050	Fail-safe	Note 4	Joint separation, Note 5
Lower angle beam to centerbody flange	SEG39135758	EWB 0.50-20	200	Tension = 11715 Shear = 855	0.82	0.06	Fail-safe	Note 4	Total thread shear ultimate, Note 5 -0.47 Joint separation

Keel angle joint to lower centerbody bolts	SEG39135769	EWB 0.50-20	200	Tension = 2533 Shear = 1665	0.79	0.09	Fail-safe	Note 4	Total thread shear ultimate, Note 5
Vertex bracket to PAS platform	SEG39135812	A 286 0.375-24	180	Tension =319 Shear =774	0.69	0.37	Fail-safe	Note 4	Combined tension and shear ultimate, Note 5
Rear bracket to PAS platform	SEG39135812	EWB 0420 0.375-24	200	Tension = 2507 Shear =6351	0.79	0.019	Fail-safe	Note 4	Combined tension and shear ultimate, Note 5

Notes:

- 1) The components will be classified as per JSC25863A, August 1998 to comply with NASA-STD-5003, October 1996 and SSP 30558 Rev. B, June 1994.
- 2) The component will be classified as fracture critical as per sect 5.2 and will be shown acceptable by compliance with sect. 6.0 of JSC25863A
- 3) The component will be classified as low risk as per section 5.1.L.1, 5.1.L.2.A and 5.1.L.2.B.3 of JSC 25863A and will be shown that the component possesses acceptable durability (Possesses acceptable resistance to crack growth)
- 4) The component will be classified as fail-safe as per section 5.1.c of JSC 25863 A
- 5) Ref. AMS-02, USS-02 Stress analysis Report

## Fracture Classification of AMS-02 UPS

Item	Drawing number	Material and temper	Material allowable stress (ksi)	Max. applied stress (ksi)	Ratio of applied stress to allowable stress	Margin of Safety (ult) FS=2.0	Fracture Classification	Rationale	Comments
UPS boxes		7075-T7351	66	8.6	0.13	2.82	Low risk	Note 2	Note 3
<b>Fasteners</b>									
Item	Drawing Number	Material and temper	Material allowable stress (ksi)	Applied Load (lbf)	Ratio of applied limit stress to allowable stress	Margin of Safety FS =1.0	Fracture Classification	Rationale	Comments
UPS Box to bracket bolts		0.25-28 A-286	160	Tension = 159 Shear = 395	0.62	0.16	Fail-safe	Note 4	Total thread shear, Note 5
Bracket to USS bolts		0.25-28 A-286	180	Tension = 178 Shear = 204	0.60	0.52	Fail-safe	Note 4	Combined tension and shear, Note 6

Notes:

- 1) The components will be classified as per JSC25863A, August 1998 to comply with NASA-STD-5003, October 1996 and SSP 30558 Rev. B, June 1994.
- 2) The component will be classified as low risk as per sect. 5.1.L.1, 5.1.L.2. A, 5.1.L.2.B3 of JSC25863 A and will be shown that the component possesses acceptable durability (possesses acceptable resistance to crack growth)
- 3) Ref. UPS structural Analysis Report, CSIST, Taiwan, May 27, 2005
- 4) The component will be classified as fail-safe based on sect. 5.1 c of JSC 25863 A
- 5) Ref. PDF bolts\_insert\_20060116, 1/16/2006
- 6) Ref. PDF bolts\_nut\_20060116, 1/16/2006

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## Fracture Classification of AMS-02 E-Crates

Item	Drawing number	Material and temper	Material allowable stress (ksi)	Max. applied tensile stress (ksi)	Ratio of applied limit stress to allowable stress	Margin of Safety (ult) FS=2.0	Fracture Classification	Rationale	Comments
Bottom plate		7075-T7351	62.9	13.5	0.21	1.336	Low risk	Note 2	Page 50, Note 5
Lateral wall		7075-T7351	62.9	8.9	0.14	2.53	Low risk	Note 2	Page 50, Note 5
<b>Fasteners</b>									
Item	Drawing Number	Material and temper	Material allowable stress (ksi)	Applied Load (lbf)	Ratio of applied limit stress to allowable stress	Margin of Safety FS =1.0	Fracture Classification	Rationale	Comments
E-Crates to USS-02	Joint 1	A 286 0.190-32 NAS1351N3	160	Tension = 1202 Shear = 248	0.64	0.22	Fail-safe	Note 3	Total thread shear ultimate, Note 4
Lateral walls to bottom plate	Joint 2	A 286 0.190-32 NAS1351N3	160	Tension = 545 Shear = 679	0.61	0.28	Fail-safe	Note 3	Combined tension and shear, Note 4
Side wall bolts	Joint 3	A 286 0.164-32 NAS1351N08	160	Tension = 391 Shear = 315	0.61	0.39	Fail-safe	Note 3	Combined tension and shear, Note 4

Notes:

- 1) The components will be classified as per JSC25863A, August 1998 to comply with NASA-STD-5003, October 1996 and SSP 30558 Rev. B, June 1994.
- 2) The component will be classified as low risk as per section 5.1.L.1, 5.1.L.2.A and 5.1.L.2.B.3 of JSC 25863 A and will be shown that the component possesses acceptable durability (Possesses acceptable resistance to crack growth)
- 3) The component will be classified as fail-safe as per section 5.1.c of JSC 25863A
- 4) Ref. AMS-02 Bolt Analysis\_Update\_v4.(1), 8/4/2005
- 5) Ref. AMS02-RP-CGS-003, issue 2,August 8, 2005, Carlo Gavazzi Space

Fracture Certification for TRD Composite structures							
Components	Material	Manufacturers Name	Basis for material properties	Quality Control	NDE Techniques	Sample tests	Damage Control Plan
Octagon Panels sidewalls	Carbon fiber skin M40J/EP Honey comb Al. 5056 core	ADCO GmbH Aachen Germany	ADCO Data sheets	Note 8	Note 9a	Notes 3,4,5,6	Note 10
Bulkheads	Carbon fiber skin M40J/EP Honey comb Al. 5056 core	ADCO GmbH Aachen Germany	ADCO Data sheets	Note 8	Note 9b	Notes 3,4,5,6	Note 10
Upper plate	Carbon fiber skin M40J/EP Honey comb Al. 5056 core	ADCO GmbH Aachen Germany	ADCO Data sheets	Note 8	Note 9b	Notes 3,4,5,6	Note 10
Lower cover	Carbon fiber skin T300/EP Honey comb Al. 5056 core	Euro composites Echternach Luxembourg	Euro Composites Data sheets	Note 8	Note 9b	Notes 3,4,5,6	Note 10

- Notes:
- 1) TRD Octagon panels Pull Test, RWTH, Aachen, 3/15/2005
  - 2) Venting of parts of TRD detector, RWTH, Aachen, 12/13/2004
  - 3) Side Panel skin tension and Bending test samples, ams 2000a
  - 4) Side panel bending test coupons, ams2001a
  - 5) Side Panel Joint test coupon, ams2003\_1a
  - 6) Side Panel Corner Junction test coupon, ams2003\_2a
  - 7) Panel specimen locations, ams2004a
  - 8) Manufacturer Certificate of Conformance will be supplied
  - 9a) NDE includes visual inspection and dimensional verification on 3D measuring device as well as static load test(including acoustic loads) on a sample side panel( RWTH, Aachen/ISAtec, 19/1/2004)
  - 9b) NDE includes visual inspection and dimensional verification on 3D measuring device
  - 10) Damage Control plan will be implemented as per ANSI/AIAA-S081

Fracture Certification for TRD Gas System Composite Structures							
Components	Material	Manufacturers Name	Basis for material properties	Quality Control	NDE Techniques	Sample tests	Damage Control Plan
Xenon tank	Carbon fiber overwrapped stainless steel	ARDE	ARDE Catalog	Note 4	Note 5	Note 1	Note 10
CO2 tank	Carbon fiber overwrapped stainless steel	ARDE	ARDE Catalog	Note 4	Note 5	Note 2	Note 10
Straw tubes	Kapton	Lamina dielectics West Sussex, UK	Manufacturer Catalog	Note 4	Note 6	Note 9	Note 10
Longitudinal stiffeners	Carbon fiber	Secar Murzzusschlag Austria	Manufacturer Catalog	Note 4	Note 7	Note 9	Note 10
Transverse stiffeners	Carbon fiber	Secar Murzzusschlag Austria	Manufacturer Catalog	Note 4	Note 7	Note 9	Note 10

- Notes:
- 1) ARDE Qualification by similarity Report of Xenon Tank PN D4815 to PN D 4636, EG10330, July 6, 2001
  - 2) ARDE Qualification by similarity Report of CO2 Tank PN D4816 to PN D4683, EG10331 July 6, 2001
  - 3) NDE tests on straw tubes by pressure drop measurement at 1.8 bar overpressure
  - 4) Manufacturers Certificate of Compliance will be supplied
  - 5) ARDE tanks are ultrasonically inspected
  - 6) NDE on Straw tubes is done by pressure drop measurement at 1.8 bar overpressure
  - 7) NDE on Longitudinal and transverse stiffeners include visual inspection, Dimensional and straightness verification
  - 8) Assembly work of straw tubes, Longitudinal and transverse stiffeners are done at the clean room in Aachen, Germany
  - 9) Sample tests include determination of Modulus of elasticity by Eigen frequency on a shaker
  - 10) Damage Control plan will be implemented as per ANSI/AIAA-S081

Fracture Certification for Silicon Tracker Composite structures							
Component	Material	Manufacturers Name	Basis for material properties	Quality Control	NDE Techniques	Sample tests	Damage Control Plan
Sandwich facing	Carbon fiber HYE 3454-3J M55 Torayca Fiberite	Contraves AG Zurich	Contraves Catalog	Note 1	Note 4	Notes 2	Note 5
Sandwich core	Al. core 5056	Hexcel	Hexcel Catalog	Note 1	Note 4	Note 3	Note 5
Tracker Shell	Carbon fiber HYE-M55G 954-3 fiberite	ADCO, Aachen Germany	ADCO Catalog	Note 1	Note 4	None	Note 5
Tracker Conical flange	Carbon fiber M55J CE3	ADCO, Aachen Germany	ADCO Catalog	Note 1	Note 4	None	Note 5

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Notes:

- 1) Manufacturers Certificate of Conformity will be supplied
- 2) Flatwise tensile test on Sandwich facing, traction tests at 90 deg,
- 3) Insert tests to validate modification of tracker planes, Contraves Report No. W-ET 99.11.15-1, 15 November 1999
- 4) NDE tests include Electrical continuity tests, Insert proof load test and Interface geometry measurement (Metrology)
- 5) Damage Control Plan will be implemented as per ANSI/AIAA S-081

Fracture Certification for AMICA Star Tracker Composite structures							
Component	Material	Manufacturers Name	Basis for material properties	Quality Control	NDE Techniques	Sample tests	Damage Control Plan
Upper support bracket	CFRP M55J Fiber ACGLTM110 Cyanate Ester resin	Advanced Composites UK RIBA Composites Italy	Advanced Composites and RIBA Composites catalog	Note 1,2	Note 3	Note 4	Note 5,7
Lower support bracket	CFRP M55J Fiber ACGLTM110 Cyanate Ester resin	Advanced Composites UK RIBA Composites Italy	Advanced Composites and RIBA Composites catalog	Note 1,2	Note 3	Note 4	Note 5,7
Attachment between upper bracket and Tracker Conical Flange	Hysol EA 9394	Loctite Aerospace California, USA	Loctite Catalog	Note 1,2	Note 3	Note 4	Note 5,7

## Notes

- 1) AMICA Star Tracker Support Fracture Control for Composite Parts,AMS-AST-Q1104-i1, 12 july 2005  
AMS-AST-Q1104-i1,12 July, 2005
- 2) Certificate of Conformance for all materials are included in Ref. 1, sect 10.2
- 3) NDE tests for all materials include Visual, Ultrasonic and 3d inspection
- 4) Material testing and certification is done. Ref. 2, sect 10
- 5) AMICA Star Tracker Support Structure handling procedures, Ref 1 sect 11.4,11.5
- 6) Star Tracker Support Structure venting, ASTS\_Venting\_040705, July 4, 2005
- 7) Damage Control Plan will be implemented as per ANSI/AIAA S-081

Fracture Certification for Ring Imaging Chernkov Counter (RICH) Composite structures							
Component	Material	Manufacturers Name	Basis for material properties	Quality Control	NDE Techniques	Sample tests	Damage Control Plan

Aerogel Radiator	Prepreg-1-42%-3KHS-P-193	Plyform Milan, Italy	Plyform Catalog	Note 1,2	Note 1,2	None	Note 3
Reflector	Bryte M46 J/EX-1515 Epibond 1210-AB	Composite Mirror Applications Tucson, Arizona	Technical data sheets	Note 4	Note 4	Note 5	Note 4

Notes: 1) Quality assurance , Plyform document Carlo Gavazzi Space, 16 December 2004

2) Plyform Certification of Conformity, 21 February 2005

3) Damage Control Plan will be implemented as per ANSI/AIAA S-081

4) Certificate of Conformance, CMA document 10025, 8/31/2005, contains Cof C for all materials, Technical data Visual inspection, Material, Quality assurance, process information and handling Procedures and Coordinated Measuring Machine Measurements (CMM).

5) Micro VCM test per ASTM E-595-90

#### Fracture Certification for Electromagnetic Calorimeter (ECAL) Composite structures

Component	Material	Manufacturers Name	Basis for material properties	Quality Control	NDE Techniques	Sample tests	Damage Control Plan
Honey comb Panels	Al core	Capital Aerospace Machinery Corp. Beijing, China	Manufacturer Catalog	Note 1	Note 2	Note 3	Note 4

Notes:

1) Manufacturers certificate of Conformity will be supplied

2) NDE Techniques

3) Sample tests

4) Damage Control Plan will be implemented as per ANSI/AIAA S-081

#### Fracture Certification for Main Radiator Composite Structures

Components	Material	Manufacturers Name	Basis for material properties	Quality Control	NDE Techniques	Sample tests	Damage Control Plan
Ram radiator Panel Sandwich core	Rohacell 52 PMI foam	Plyform Italy	Plyform Brochure	Note 1,6	Note 5	Notes 2,3,4	Note 7
Wake Radiator Panel Sandwich core	Rohacell 52 PMI foam	Plyform Italy	Plyform Brochure	Note 1,6	Note 5	Notes 2,3,4	Note 7

Notes:

- 1) Manufacturers Certificate of Conformity will be supplied
- 2) Insert test performed by DLR ( German Aerospace Center) Institute of Structural Mechanics, Doc. No 059-00-TB-01, 19 April, 2004
- 3) Insert test samples produced by Invent GmbH, Germany
- 4) Tension and Shear tests are done and results shown in Report No. 059-00-TB-01
- 5) Fokker Bond test (ultrasonic) on all parts
- 6) Incoming inspection (FAW, Resin content) as per ASTM Specification
- 7) Damage control plan will be implemented as per ANSI/AIAA S-081

#### Fracture Certification for Tracker Radiator Composite Structures

Components	Material	Manufacturers Name	Basis for material properties	Quality Control	NDE Techniques	Sample tests	Damage Control Plan
Ram radiator Panels sandwich core	Rohacell 51 IG PMI foam	Plyform Italy	Plyform Brochure	Note 1,4, 5	Note 3	Note 2	Note 6
Wake Radiator Panels sandwich core	Rohacell 51 IG PMI foam	Plyform Italy	Plyform Brochure	Note 1,4, 5	Note 3	Note 2	Note 6
Attachment Rods	CFRP Tenax	Plyform Italy	Plyform Catalog	Note 1,4, 5	Note 3	Note 2	Note 6

Notes:

- 1) Manufacturers Certificate of Conformity will be supplied
- 2) Mechanical tests on specimens (prepregs, Joints, adhesives)
- 3) Every piece is tapped and for critical application ultrasonic resistance (Fokker bond test ) is done
- 4) Raw material conformance certificates are collected
- 5) Incoming inspections (FAW, Resin content) as per ASTM specs.
- 6) Damage Control Plan will be implemented as per ANSI/AIAA S-081

#### Fracture Certification for Zenith Radiator Composite Structures

Components	Material	Manufacturers Name	Basis for material properties	Quality Control	NDE Techniques	Sample tests	Damage Control Plan
Radiator Panels	Rohacell 52 PMI Foam	Plyform Italy	Plyform Brochure	Note 1	Note 5	Note 2, 4	Note 6

Sandwich core							
Interface Spokes	GFRP	Plyform Italy	Plyform Brochure	Note 1	Note 5	None	Note 6
Z Bracket	GFRP	Plyform Italy	Plyform Brochure	Note 1	Note 5	None	Note 6

Notes

- 1) Manufacturers Certificate of Conformity will be supplied
- 2) Insert test performed by DLR ( German Aerospace Center) Institute of Structural Mechanics, Doc. No 059-00-TB-01, 19 April, 2004
- 3) Insert test samples produced by Invent GmbH, Germany,
- 4) Tension and Shear tests are done and results shown in Report No. 059-00-TB-01
- 5) Fokker Bond Tests(ultrasonic) on all parts
- 6) Damage Control Plan will be implemented as per ANSI/AIAA S-081

#### Fracture Certification for Upper Time of Flight (UTOF) Composite Structures

Components	Material	Manufacturers Name	Basis for material properties	Quality Control	NDE Techniques	Sample tests	Damage Control Plan
Sensor boxes	Carbon fiber	Euro composites Hexcel	Manufacturer Catalog	Note 1			
Scintillator cover	Carbon fiber	Euro composites Hexcel	Manufacturer Catalog	Note 1			
Scintillator core	Plexiglass			Note 1			
Scintillator supports	Carbon fiber			Note 1			
PMT boxes Support	Carbon fiber	Euro composites	Manufacturer Catalog	Note 1			

Notes:

- 1) Manufacturers Certificate of Conformance will be supplied
- 2) NDE techniques
- 3) SampleTests

### Fracture Certification for Lower Time of Flight (LTOF) Composite Structures

<b>Components</b>	<b>Material</b>	<b>Manufacturers Name</b>	<b>Basis for material properties</b>	<b>Quality Control</b>	<b>NDE Techniques</b>	<b>Sample tests</b>	<b>Damage Control Plan</b>
Sensor Boxes	Carbon fiber		Manufacturer Catalog	Manufacturer certification	Approved NDE methods		Implement as per ANS/AIAA-S/081
Boxes/PMT Supports	Carbon fiber		Manufacturer Catalog	Manufacturer certification	Approved NDE methods		Implement as per ANS/AIAA-S/081
Scintillator core	Plexiglass		Manufacturer Catalog	Manufacturer certification	Approved NDE methods		Implement as per ANSI-S/081
Scintillator cover	Carbon fiber						Implement as per ANSI-S/081

Notes:

- 1) Manufacturers Certificate of Conformity will be supplied
- 2) NDE techniques
- 3) Sample tests

### Fracture Certification for Anti Coincidence counter (ACC) Composite Structures

<b>Components</b>	<b>Material</b>	<b>Manufacturers Name</b>	<b>Basis for material properties</b>	<b>Quality Control</b>	<b>NDE Techniques</b>	<b>Sample tests</b>	<b>Damage Control Plan</b>
ACC cylinder	Carbon fiber	IKV (Institut fur Kunststoff verarbeitung, Aachen, Germany)	Manufacturer catalog	Note 1, 3	Note 4	None	Note 5

Notes:

- 1) Certificate of Conformance will be supplied
- 2) Machining of cylinder at Physikalische Institut RWTH, Aachen, Germany
- 3) Quality control includes Computer controlled filament winding, curing cycle and mass report
- 4) Assembly work at RWTH Aachen has been done in restricted area
- 5) Damage control will be implemented as per ANSI/AIAA S-081



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## Memorandum

**Date** 4 Jul 2005 **Memo #:** ESCG-4039-05-SP-DO-0003  
**To** Leland Hill  
**From** Chris Tutt  
**Subject** Creep in the AMS-02 Composite Straps

References:

- [1] Fax #693, John Ross to Trent Martin, "Creep in Composites," 17 Jul 2001.
- [2] Davidson, Roger, "Creep in Polymers and Composites," Crompton Technology Group, 14 Jun 2001.
- [3] MIL-HDBK-17F, *Composite Materials Handbook*.

As part of the safety verification process of the AMS-02 payload, I have reviewed all data available on creep of the composite strap systems to see if the cryomagnet support straps will be expected to creep significantly, and thus lose preload, during the duration of the mission. An initial order of magnitude calculation was provided by Space Cryomagnetics Ltd. during the initial design stages, which was based on technical data provided by Crompton Technology Group [2]. At that time, the projected loss of preload after three years was projected to be 1.6 lb. This is a trivial amount and will have no effect on the payload's structural response. In this memo, my goal is to review this calculation based on the matured magnet design and demonstrate that this conclusion still holds.

Creep in composites is primarily a high-temperature phenomenon, affecting materials which are more than 50°C above the material glass temperature [3]. Three of the four bands in the AMS-02 strap system are at cryogenic temperatures and thus need not be considered for creep. The remaining band is the S2-glass band.



## Memorandum (Continued)

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Test-measurements of glass fiber loaded to 32% of ultimate load at room temperature show a creep rate of  $3.9 \times 10^{-4} \%/\text{hr}$  [2]. To estimate the total load, we need to estimate the maximum sustained load in each of the three configurations of the magnet:

- 1) Preload + 1g in the -Z direction.  
25 months assembly and testing at SCL, CERN, and KSC. (18,000 hr)  
Maximum sustained load is 2700 lb.
- 2) Preload +1g in the +X direction.  
One month of assembly time and one month in the canister at KSC. (1440 hr)  
Maximum sustained load is 3198 lb.
- 3) Preload only, no gravity.  
Three years of on-orbit lifetime. (25,920 hr)  
Maximum sustained load is 1750 lb for C1W1 straps.

For each of these configurations, we can calculate total sustained strain:

$$\begin{aligned}\varepsilon_1 &= 151 \mu\epsilon \\ \varepsilon_2 &= 179 \mu\epsilon \\ \varepsilon_3 &= 98 \mu\epsilon.\end{aligned}$$

Then using the creep rate listed above, calculate the predicted increase in deformation:

$$\begin{aligned}\Delta_1 &= 7.02\% \text{ of } 151 \mu\epsilon = 10.6 \mu\epsilon \\ \Delta_2 &= 0.56\% \text{ of } 179 \mu\epsilon = 1.0 \mu\epsilon \\ \Delta_3 &= 10.11\% \text{ of } 98 \mu\epsilon = 9.9 \mu\epsilon\end{aligned}$$

So at the end of assembly, launch, and the primary mission, we can expect to have no more than  $21.5 \mu\epsilon$  of permanent deformation in the glass band, or  $1.77 \times 10^{-4}$  inches. This would lead to a loss of preload of 0.5 lb. This, as before is an insignificant amount and will not lead to any change in the structural response of the cryomagnet, nor will it place the straps themselves in jeopardy.

A.1-58

## STRESS CORROSION CRACKING SUSCEPTIBLE MATERIAL APPLICATIONS SUMMARY

**Table I: Listing of SCC Susceptable Materials Used in Various Subsystems of AMS-02**

<b>Subsystem</b>	<b>Part Name/Part Number</b>	<b>Material</b>	<b>Specification</b>	<b>SCC Rating</b>
USS	Outer Cylinder, Vacuum Case Assy/ SDG39135779	AL 7050-T7451	AMS 4108	"U" per MAPTIS, Table II per MSFC-STD-3029
USS	Lower Support Ring, Vacuum Case Assy/SDG39135785	AL 7050-T7451	AMS 4108	"U" per MAPTIS, Table II per MSFC-STD-3029
USS	Upper Support Ring, Vacuum Case Assy/ SDG39135784	AL 7050-T7451	AMS 4108	"U" per MAPTIS, Table II per MSFC-STD-3029
USS	Interface Plate Assy, Upper, VCA/ SDG39135788	AL 7050-T7451	AMS 4050	"U" per MAPTIS, Table II per MSFC-STD-3029
USS	Interface Plate Assy, Lower, VCA/ SDG39135789	AL 7050-T7451	AMS 4050	"U" per MAPTIS, Table II per MSFC-STD-3029
USS	Upper Vacuum Case Interface Joint Assy, Upper USS-02 Assy/ SDG39135727	AL 7050-T7451	BMS 7-323C	"U" per MAPTIS, Table II per MSFC-STD-3029
USS	Sill Joint Assy, Upper USS-02 Assy/ SDG39135730	AL 7050-T7451	BMS 7-323C	"U" per MAPTIS, Table II per MSFC-STD-3029
USS	Bridge Beam Elbow, Lower Trunnion/ SDG39135734	AL 7050-T7451	BMS 7-323C	"U" per MAPTIS, Table II per MSFC-STD-3029
USS	Interface Joint Assy, Lower VC, Lower USS-02 Assy/ SDG39135737	AL 7050-T7451	BMS 7-323C	"U" per MAPTIS, Table II per MSFC-STD-3029
USS	Bracket, Sill, Upper USS-02 Assy/ SDG39135738	AL 7050-T7451	BMS 7-323C	"U" per MAPTIS, Table II per MSFC-STD-3029
USS	Diagonal Bracket, Sill, Upper USS-02 Assy/ SDG39135740	AL 7050-T7451	BMS 7-323C	"U" per MAPTIS, Table II per MSFC-STD-3029
USS	Centerbody Box Joint Keel Interface Assy, Lower USS-02 Assy/ SDG39135759	AL 7050-T7451	BMS 7-323C	"U" per MAPTIS, Table II per MSFC-STD-3029
USS	Centerbody Box Joint Assy, Lower USS-02 Assy/ SDG39135760	AL 7050-T7451	BMS 7-323C	"U" per MAPTIS, Table II per MSFC-STD-3029
USS	Joint Assy, Lower USS to Upper USS, Lower USS-02 Assy/ SDG39135762	AL 7050-T7451	BMS 7-323C	"U" per MAPTIS, Table II per MSFC-STD-3029
USS	RICH Mounting Bracket, Lower USS-02 Assy/ SDG39135763	AL 7050-T7451	BMS 7-323C	"U" per MAPTIS, Table II per MSFC-STD-3029
USS	PAS RICH Bracket Assy, Lower USS-02 Assy/ SDG39135766	AL 7050-T7451	BMS 7-323C	"U" per MAPTIS, Table II per MSFC-STD-3029
USS	Lower Angle Beam Flange, Lower USS-02 Assy/ SDG39135767	AL 7050-T7451	BMS 7-323C	"U" per MAPTIS, Table II per MSFC-STD-3029
USS	Keel Angle Joint, Keel Assy/ SDG39135769	AL 7050-T7451	BMS 7-323C	"U" per MAPTIS, Table II per

**Table I: Listing of SCC Susceptable Materials Used in Various Subsystems of AMS-02**

Subsystem	Part Name/Part Number	Material	Specification	SCC Rating MSFC-STD-3029
USS	Keel Block Assy, Keel Assy/ SDG39135770	AL 7050-T7451	BMS 7-323C	"U" per MAPTIS, Table II per MSFC-STD-3029
USS	PAS Platform Assy, PAS Base Assy/ SDG39135817	AL 7050-T7451	BMS 7-323C	"U" per MAPTIS, Table II per MSFC-STD-3029
USS	Bridge Assy, PAS Bridge Assy/ SDG39135837	AL 7050-T7451	BMS 7-323C	"U" per MAPTIS, Table II per MSFC-STD-3029
USS	UMA Bracket/ SDG39135858	AL 7050-T7451	BMS 7-323C or AMS 4108	"U" per MAPTIS, Table II per MSFC-STD-3029
USS	PVGF Bracket/ SDG39135860	AL 7050-T7451	BMS 7-323C or AMS 4108	"U" per MAPTIS, Table II per MSFC-STD-3029
USS	FRGF Bracket/ SDG39135861	AL 7050-T7451	BMS 7-323C or AMS 4108	"U" per MAPTIS, Table II per MSFC-STD-3029
USS	Scuff Plate/ SDG39135867	AL 7050-T7451	BMS 7-323C or AMS 4108	"U" per MAPTIS, Table II per MSFC-STD-3029
RICH	Breather Valve, Aerogel Container/ RICH-C790RPVXX	AL 2011-T3	TBD	"C" per MAPTIS, Table III per MSFC-STD-3029
Cryomag	AMS-02 Helium Tank/ TBD	AL 5083-H111	TBD	"B" per MAPTIS, Table II per MSFC-STD-3029
Tracker	Ladder Feet and Inserts/ AMS1101 and AMSII-148	AL 7075-T6	TBD	"C" per MAPTIS, Table III per MSFC-STD-3029
Tracker	Thermal Bars and Bridge Bracketry/ AMSII-179, AMS2002	AL 5083-O	TBD	"B" per MAPTIS, Table II per MSFC-STD-3029